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EDITORIAL.

TECHNICAL SCIENTIFIC EDUCATION.

MUCH interest has been excited in England by a letter from Dr. Playfair, lately published in the *Times*, which represents the evidences of improvement and progress furnished by articles placed in the Paris Exhibition, as much less marked in the English department than in the collections of some other nations, and traces this difference to the superior facilities offered in the latter countries for general scientific and technical education.

The School Inquiry Commission have addressed, officially, inquries on this subject, to the other English jurors, and the various answers received are wonderfully concordant, both as to the fact of a great difference in progress on the part of different nations, and also as to the relation of this difference to the educational facilities existing in the various cases.

Thus Tyndall says, * * * "In fact, I have long entertained

the opinion that, in virtue of the better education provided by continental nations, England must one day—and that no distant one—find herself outstripped by those nations, both in the arts of peace and war. As sure as knowledge is power this must be the result."

Professor Frankland says, * * * "I quite agree with Dr. Playfair, in referring this want of progress in the manufactures of this country chiefly to the almost utter lack of a good preparatory education for those destined to take part in industrial pursuits."

Omitting the remarks of many others, which are all to the same effect, we finally quote from Mr. Scott Russell, who, after a very full discussion of the subject in detail, says:

"Prussia, Switzerland, Belgium, France and America seem to make progress in proportion to the excellence of their educational training."

In fact, there seems to be overwhelming testimony, from the best authority, in proof of what is in itself eminently probable, namely, that they who know the most will learn the most in addition, and that the most valuable discoveries and inventions will be reached by those who, having a sound knowledge of general principles and of previous labors, can devote their whole force to the development of the *new* and the *possible*, and waste no energy on the redevelopment of what has been already exhausted, or the devising of combinations utterly ineffective, because ignoring the actual properties of matter and the essential laws of force.

That we, as well as the manufacturers of England, should take the lesson to heart and act energetically upon its teachings, is evident to the most casual observer.

An hour's study of the patent reports, or of any publication announcing indiscriminately all new (?) inventions, will show us that far more than half, even of those exhibiting considerable ingenuity and practical acquaintance with the special subject treated, would have been either abandoned or improved (in either case with great advantage to the deviser) had he possessed even a very general groundwork of scientific knowledge.

At the present time, when facilities of intercommunication and transportation are already so great and are constantly increasing, competition is no longer confined to narrow localities or a small circle of neighborhoods, but is extended over whole continents and nationalities, and includes, or will include before long, the productive industries of the entire world.

Those nations, therefore, who, from any cause, produce the best and cheapest articles, will command the universal market, to the exclusion of others less successful.

In view of these possibilities of the future—or we may even say, these facts of the present—it behooves us as a nation and as individuals, interested collectively and personally in the progress of technical science, to neglect no means by which an advanced position may be secured and maintained.

That the general diffusion of scientific knowledge among our people, is the most direct and efficient means for securing this result, needs little proof.

We will, however, quote from the letter of Mr. James Young (one of those above mentioned) some statements, which are not only forcible in *themselves* in this regard, but also will recall to our readers numerous like cases, familiar to all, and establishing the same conclusions. Mr. Young says:

"Permit me to use my own case as an illustration. Originally I was a working man, but have succeeded in increasing the range of manufacturing industry. The foundation of my success consisted in my having been fortunately attached to the laboratory of the Andersonian University of Glasgow, where I learned chemistry under Graham, and Natural Philosophy and the other subjects under the respective professors. This knowledge gave me the power of improving the chemical manufactures into which I afterwards passed as a servant, and ultimately led to my being the founder of a new branch of industry and owner of the largest chemical manufactory in the kingdom." Such cases (of which scores might be cited) are unanswerable arguments as to the advantage of general scientific education, not only to individuals, but to the public or nation at large. Not every one, it is true, who has scientific knowledge, is able to apply it usefully; but just for that reason is it important that the seed of knowledge should be widely scattered, that its chance of finding fruitful soil may be increased.

The means by which this diffusion may be secured are numerous.

In our collegiate establishments, more attention should be given to physical studies, even at the expense of a diminution in the classical departments. When universities and the like were first established, the only learning which existed and could be made the subject of study and instruction, was the classical.

Chemistry was unborn, geology, mineralogy, and like branches,

not even imagined, the laws of light, heat, and electricity utterly unknown and unsought.

Exclusive devotion to classical studies was, therefore, at that time appropriate, natural and necessary. But now, when these new sciences have developed an amount of material in comparison with which the whole mass of classical lore is but as an atom, and (except as a mental discipline) practically valueless, it is certainly neither appropriate nor necessary, however natural it may be, to keep in the old track, and to devote to these extensive, grand and useful departments of human knowledge but a fraction of the time and attention assigned to the classics.

We do not wish to disparage the advantages of classical education. Having enjoyed the benefits of a full collegiate course, we realize its effects and value the mental training which it affords; but while this is good, we cannot but believe that the same amount of time and effort devoted to physical studies, say to analytical chemistry and optics, or mechanics, would have been as useful an exercise to the mind, and at the same time would have furnished a far more valuable and practically useful store of information.

In the next place, besides thus furnishing thorough means of instruction to those who can devote much time to its acquirement, we should do all that is possible to aid and encourage those who, with less opportunity and leisure, may, nevertheless, be equally benefited, and in turn be enabled to benefit others by an equally true, if less thorough, course of instruction.

With this view all, however indirectly interested in the progress of manufacturing industry (and this means, in fact, the whole community, the foundation of whose wealth lies in these useful arts), should regard it as a duty to themselves, their fellow-citizens and their country, to aid, in every way they are able, in supporting and extending those institutions which have for their aim this very object, *i. e.* the diffusion of scientific knowledge among the public at large. The mere question of direct immediate personal benefit, is foreign to the subject. It is their duty to support these institutions as it is their duty to support their government, not because they expect to occupy its offices or sit in its assemblies, but because by its means are secured their prosperity, safety and hopes of future advance.

In no direction is more fully exhibited the wisdom of the generous policy "that scattereth and yet increaseth."

The energy and originality of the American people are already

world-renowned, and if to this we can but add the necessary amount of knowledge, to direct this energy and make fully available this originality, the brightest of futures may be anticipated for our arts and industries.

ENGINEERING ITEMS.

The velocity of steam.—In the *Mechanics' Magazine*, p. 271, we find noticed a pamphlet by R. D. Napier, on the above subject, which we hope before long to have the opportunity of examining.

Two of the most remarkable statements in this pamphlet are given in the above notice, and are said to be well supported, not only by clear reasoning, but by careful and repeated experiment. These propositions are certainly worthy of note, and, if substantiated, will introduce some marked changes in our received formulæ. They are as follows:

First. The greatest rate at which steam will flow from an orifice into a vacuum, is only half of that generally stated and given in the tables published on this subject.

Second. Steam or any other gas, at a given pressure, will rush into any pressure less than half its own, exactly as into a vacuum. Thus, steam at anything over two atmospheres will escape into the air, or into a vacuum at the same rate. We have not the essay in question before us, and, therefore, can form no judgment of its force or reliability. We can merely state the proposition as above, and repeat, that the writer in the journal quoted speaks of them as well and clearly substantiated.

The Rodman gun in England.—We learn from *Engineering* of July 5th, that the gun sent to England for trial was put to preliminary test with results eminently satisfactory and to its credit.

With thirty-five pounds American powder and a ball of four hundred and fifty pounds, its range was on the average seven hundred and eleven yards, point blank, over a level surface, the range being measured by the first graze.

The deflection was at the greatest six yards, but some shots were absolutely *on the line*. Velocity with this charge, about nine hundred and twenty feet per second. With fifty pounds same powder, range nine hundred and eighty-two yards; deflection two to three yards; velocity one thousand one hundred and ten to one thousand one hundred and thirty-three feet per second.

With sixty pounds same powder, range one thousand one hundred and thirty-eight yards; velocity one thousand two hundred and ten feet; deflection one to four yards.

With thirty-five pounds English powder, range eight hundred and seventy-three yards; velocity one thousand and forty-four feet; absolutely true.

With fifty pounds English powder, best range one thousand one hundred and forty yards; velocity one thousand two hundred and fourteen feet; deflection two to four yards; one shot absolutely true.

A cement for attaching glass and brass is stated to be prepared of excellent quality, by first forming a resin-soap by boiling three parts of resin and one part of caustic soda in five parts of water, and then mixing this with half its weight of plaster of paris. This cement is said to be impervious to petroleum, only superficially affected by water, to adhere very strongly and to be a bad conductor of heat.

Lighting-gas in India.—For two years past the cities of Bombay and Singapore have been supplied with lighting-gas. Notwithstanding the opposition at first experienced from the prejudices of the native inhabitants, the enterprise is proving successful in both cases, the new light being employed even in the native temples.

The coal used by preference, is that obtained from Australia; which, besides being cheaper, is much more free from sulphur, by reason of which not only is the gas more readily purified, but also a large supply of coal can be stored, without deterioration or danger from heating.

A Locomotive for common roads, built on the Lutz system, lately started from Nantes and proceeded to Orleans, passing through Angers, Sanmuer, Tours, Blois and Amboise. Its speed varied from twelve and a half to fifteen and a half miles per hour.

Pacific Railway.—Having from time to time noticed the progress made on the above work from this side, we now take from the *Engineering* a statement furnished by Mr. Geo. E. Grey, consulting engineer of the road, now in London:

"The Central Pacific Railroad of California, commences the ascent of the foot hills of the Sierra Nevada mountains seven miles from Sacramento (tide-water of the Pacific), and from thence to the summit of the mountain pass, 7042 feet, and 105 miles distant, there is a continuous series of heavy ascending grades and sharp curves. The

maximum gradients on this portion of the line are 1 in 45½, of which, however, there is less than six miles, and the sharpest curves are 575 feet radius, but there are only a very few examples of this kind.

"The Sierra Nevada mountains are remarkably forbidding in appearance and reality for the purposes of railway building and operating; and to those who are unacquainted with this mountain topography, and accustomed to the lesser elevations and gentler slopes of Europe and the Atlantic States, it will be difficult to convey an adequate idea of the irregularites of surface which attach to them. The general direction of this mountain range is parallel with the coast, and the western slope is intersected by numerous rivers and their tributaries, having their sources near the summit of the Sierras. The rivers run through deep gorges or canons, in many places from 1000 to 2000 feet in depth, with sides varying from perpendicular to slopes of 45 degrees. The ridges between these water courses are sharp, well-defined, and in many places so narrow on the top as to leave barely room for a wagon road to be made without excavating the surface of the ridge. The branches of many of the rivers course through canons as deep as those of the rivers themselves, and present physical barriers to lines of communication crossing them in a northerly and southerly direction.

"The short distance from the western terminus to the summit, 105 miles, and the deep canons to be avoided, rendered it necessary to adopt steep grades and sharp curves to attain the summit elevation; but all these formidable difficulties have now been nearly overcome, the line is completed and in operation to within twelve miles of the summit, and the earthworks and bridging are nearly completed for fifty miles eastward to the eastern base of the mountains; and this latter portion of the line will be completed and opened for traffic by the 1st of November next.

"By the 1st of September, however, the rails will be laid to the summit of the pass, and then the locomotive steam-whistle will sound its sharp notes from a greater elevation than it has ever before attained, marking an important event in the era of railway enterprise.

"From the eastern base of the mountains for about 575 miles, to Salt Lake, the construction of the railroad, for its extent, is remarkably easy and cheap, the greatest cost being, equipments, cross-ties and iron. The line follows the valley of the Truckee River down to the big bend (where the river turns abruptly to the north), and from

there to the valley of the Humboldt River, to nearly its source, thence to Salt Lake, and the initial point of meeting the Union Pacific Railroad from the east.

"The construction of 150 miles of the mountain road, and that, too, across one of the most formidable ranges in the world, where so few important streams are crossed, and so small an amount of bridging actually required, presents an anomaly in the history of railroad enterprise.

"The company are building and equiping the road in a first-class manner throughout; their locomotives, cars, &c., are of superior materials and workmanship, and the iron rails are of the most approved American pattern, weighing sixty pounds per yard, the joints of the rails being fished with wrought iron plates, bolts and nuts.

"The tunneling is not of any great extent, and the material pierced is generally of such a character as not to require lining. The longest tunnel on the line is at the summit of the Sierra Nevada, and it will extend sixteen hundred and fifty-eighth feet through a very hard, tough granite. The progress here was rather slow in the outset, but the introduction of nitro-glycerine as a substitute for powder has enabled the company to make rapid progress since. It is estimated this tunnel will be completed by the 1st of September. All the other tunnels are completed. Wherever cuttings have occurred in constructing the mountain work, rock has been found in all conditions of hardness, from the softest slates and shales to the hardest serpentine and granite.

"Wherever trestle bridging has been employed, it has been planned with a view to strength, safety and durability; the ties, stringers, corbels and caps being of best quality of pine from Puget's Sound, (nearly equal to oak,) and the posts, braces, sills and piles, of redwood. The main posts, twelve inches square, are placed perpendicularly, let into a sill twelve inches square, with mortice and tenon, directly under the bearing of the track stringers. Two posts, twelve inches by twelve inches, extend down on the outside of the main posts, with a run of one foot in three feet to the sill, to which they are tenoned, being also bolted at the top to the main posts with inch bolts and cast iron washers. The sills rest on piles, on stone foundations. When piles are used, they are so driven as to come directly under the main posts and braces.

"The posts are capped with a timber twelve inches square and nine

feet long, into which the posts are tenoned and pinned. Upon the caps rest the corbels, twelve inches square and nine feet long; upon these corbels are laid the stringers, twelve inches by fifteen inches, which are secured by iron bolts passing down through the stringers and corbels. The caps are notched one inch, to receive the corbels. Upon the stringers rest the cross-ties (or sleepers), securely fastened down to the stringers, and on these are laid the rails, which are secured in the usual manner. The "bents," or frames, are placed at intervals of fifteen feet from centre to centre.

"Trestling constructed after this manner will last from eight to fifteen years, and when renewals are necessary it can be replaced at small cost, or filled with earthen embankment by transporting material on cars at much less cost than would have been incurred in making the embankments originally.

"The revolution in the communications with China, &c., must be great when this railroad is completed. The tide of traffic across the country from ocean to ocean is already very large and on the increase, notwithstanding all the delays, discomforts and terrors of a sea voyage *via* Panama, &c.

"It now requires from twenty to twenty-three days to make the journey from New York to San Francisco *via* Panama; but when this line is completed the trip will be made within seven days, and then, in connection with the line of steamships already running regularly between San Francisco and Hong Kong, the trip can be made from New York to Hong Kong in less than thirty-five days.

"Mr. Samuel S. Montague is the chief engineer in charge of the construction of the works, having succeeded the late T. D. Judah, Esq., who made the original surveys for the location. We are indebted for the particulars of the Central Pacific Railroad above given to Mr. George E. Grey, the consulting engineer of the line, who is now in London."

Rolling liquid steel.—Some time since some experiments were made by Mr. Bessemer, in the rolling of melted steel. The plates so treated were thin and the quantity of metal employed was small, but the quality of the product obtained was admirable for its toughness.

Thus it could not only be bent over flat, but again across, so as to make a sharp corner. To treat large masses and heavy plates in the same manner, would not be an easy problem, but not beyond the possible accomplishments of the future. The various plans for treat-

ing melted Bessemer steel, noticed in our last issue, look in the same general direction, and illustrate the importance of obtaining such a result as is indicated above.

Tin-lined lead pipe.—In Volume LI. of this *Journal*, beginning with page 271, was reprinted a full account of experiments on the flow of solids through apertures, under the influence of great pressure. These experiments are of great interest in a scientific point, as serving to give practical demonstrations of many theoretical conclusions. While these additions to our knowledge, on the one hand, were being developed in Europe, an improvement of equal importance to our practical convenience was being developed in this country, in relation to the same subject. Messrs. Shaw & Willard, of New York, have reduced to practical working, a process by which a conical core of tin, surrounded by a cylinder of lead, is forced out through an annular orifice, as a continuous lead pipe, lined with tin.

The advantages possessed by this article are numerous and evident, but above all is the great point that it is certainly harmless in its effect upon the water it may be used to convey, and cannot lead to one of those distressing cases of lead poisoning which are, unfortunately, so often occurring.

The new tube is stronger, lighter and less bulky than that made entirely of lead, and seems likely to meet with very general employment.

Cast iron car wheels.—We quote from *Engineering* the following statement, which will no doubt be interesting to some of our readers, coming as it does from the able pen of Mr. Colburn, though the facts stated are, of course, generally known among our engineers. Speaking of the locomotive America, sent by the Grant Locomotive Works, of Paterson, New Jersey, the writer continues: "The wheels are of cast iron, the truck-wheels chilled, while the driving-wheels have Krupp's steel tyers. Can English engineers believe it that wrought iron wheels, of the best English makes, have been tried again and again on American lines, and abandoned as not being equal in strength and wearing qualities to cast iron wheels? But it will be said that these wheels are enormously heavy. They certainly look so, but every one of those thick spokes, and the rims also of the driving-wheels, are hollow, a network of cores being placed in the mould in casting them. The driving-wheels of the America, five feet two inches across under the tyres, weigh each but 1250 pounds, or a little over 11 cwt., irrespective of the counterweights, which weigh

270 pounds. Thus the whole wheel is but one-half heavier than the two and a half inch tyre, which weighs 835 pounds. Why is it, for such is unquestionably the fact, that English engineers no sooner go to Canada than they become firm converts to cast iron wheels? Nearly all the traffic of the Grand Trunk and the Great Western of Canada railways is now run on cast iron wheels. Of the former line, Mr. Richard Eaton, formerly Mr. Beattie's principal assistant on the London and Southwestern Railway, is the locomotive superintendent, and neither he nor Mr. C. J. Brydges, who is the general manager, and well known in London, will have anything but cast iron wheels. There are a few of wrought iron still on the line, but they are getting rid of them as fast as possible. Curiously, the complaint is that wrought iron will not stand the winter climate, or rather the discipline of a road-bed frozen as hard as if it were a bed of granite. We are speaking both of engine driving-wheels with wrought iron or steel tyres, and of chilled truck-wheels for the engines, tenders, carriages and wagons. We have copies of letters from the above-named and other Canadian engineers and railway managers, now in our possession, all speaking very strongly upon this point, and we do not doubt that when Captain Tyler goes out, in September, on the invitation of the Grand Trunk shareholders, to inspect and report upon their line, he will look closely into this question of chilled wheels, about which there is certainly great misconception in this country."

Provisions for security in iron ships.—At the late annual meeting of the Institution of Naval Architects, the above subject was formally introduced, and, as the result of action then taken, a number of important and valuable recommendations were then drawn up, for whose details we must refer our readers to the *Mechanics' Magazine*, p. 289, where a full account is given; but we may here state, that these suggestions include provision for placing in the hands of each captain correct general data as to the special constructive features of his vessel, which have a bearing on the question of her stability and safety. They also state the proper limits of free-board in connection with length and beam. They recommend strongly the employment of water-tight compartments, and suggest the most efficient and economical methods of arranging them. They advise that all openings, such as hatches, &c., should have their coverings hinged in place, or, in certain cases, where they communicate with the sea, should be protected by valves. The number and arrangement of pumps is fully discussed, the importance of proper stowage is

insisted upon, flap-boards, to clear the deck, are recommended, and many other matters of general importance and detail are enumerated.

A steel boat in sections, weighing less than forty pounds each, has been ordered by the Admiralty, to be employed in the search for Dr. Livingstone, who, it is hoped from late reports, is still alive, and somewhere on the Lake Tanganyika, in the interior of Africa. This vessel will be constructed in half sections, about two feet long, to be put together with screw-bolts; the keel will be formed of half-inch plates, and the vessel is intended to be fitted with a mast and fore and aft sails. The cost of this vessel, with its fittings, is estimated at about £1000, and will be borne by a special grant from the treasury.

NOVELTIES IN CHEMISTRY AND PHYSICS.

Magnetic phantoms.—By this name are indicated those figures composed of a combination of curves, which are produced when iron filings are scattered upon a sheet of paper placed over a magnet.

Attempts have been made to preserve these figures by attaching the filings, as arranged by the magnetic force, to paper coated with a mixture of starch and gelatine or wax and parafine. Many obvious inconveniences, however, attend both of these methods.

In the last number of *Cosmos* which we have received (July 6th), is a paper of some length by M. Stanislas Meunier, from which we translate the important practical results, as follows:

The paper on which the magnetic figures are to be developed, is prepared by saturating it with a warm solution of ferrocyanide of potassium and thoroughly drying. The magnetic phantom is then to be made, not with iron filings, but with pulverized magnetite or natural loadstone. Then a little pure gaseous hydrochloric acid is allowed to come upon the paper, &c., through an inverted funnel. After a few seconds this is removed and the paper, freed from the magnetic powder, is thoroughly washed. A figure in dark blue on a faint blue ground is then obtained, remarkable for its perfection and delicacy of detail.

Carbonic acid in sea air.—It has been of late assumed, from observations made at the request of the French Academy, by Servy, in 1848, that the amount of carbonic acid in sea air during the day is greatly in excess of that found at night, and also greater than the per centage obtained from air collected on land. An extensive series of

determinations, made during 1865 and 1866, by Mr. T. E. Thorpe, and communicated to the Literary and Philosophical Society, by Prof. H. E. Roscœ, however, show, first—That the sea does not act in increasing the amount of carbonic acid in the air. Second; on the contrary, the sea air contains less than that over the land, though the absorbtive effect is less than Vogel and Krüger indicate. Third; that the mean proportion in sea air is ·0003. Fourth; that the proportion is constant in different latitudes and does not vary with the season or hour.

Period of the November meteors.—A very thorough theoretical investigation, founded upon a comparison of the theoretical secular motion of the node for each of the five previously computed possible orbits, with the observed motion measured at the last appearance (November 1866), has been made by Professor Adams.

From this comparison he finds that the period of 35·25 years gives a calculated motion of 28′, that observed being 29′, from which he concludes that the above must be the true time of revolution, this accordance being remarkably close.

Cooking utensils in one piece.—We see that various vessels of this sort have been made from Bessemer steel, by M. Russ of Gratz, and are highly commended in the foreign journals for lightness, durability and efficiency. The plan and material are both good, but we should not fail in this connection to direct attention to the fact that vessels of a similar construction, made, however, of the best sheet iron, pressed into shape and without joints of any sort, being, moreover, thoroughly tinned, have been supplied for a long time by the firm of Higgins, Marchand & Co., whose agent in this city is George H. Bartlett, 127 Arch Street.

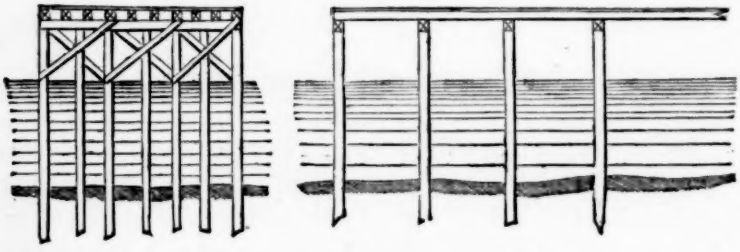
Editorial Correspondence.

OUR NEW YORK LETTER.

New York, *July*, 1867.

It is a matter of much pride to Americans, when looking over the engineering improvements and inventions of the past fifty years, both public and private, to reflect upon the large proportion of them due almost entirely to American resource, genius and enterprise.

Among public improvements, there is one branch, however, that is strangely at variance with all others, and that is pier and dock construction with their appurtenances for facilitating commerce, such as warehouses, derricks, steam-power and the like. I will speak now of the wharfage system of New York, a system at once so rotten, extravagant and wasteful of room, that it ill becomes a commerce nearly, if not quite, two-thirds in amount of that of the whole United States. The "Metropolis" is panting for more room, and hardly knows where to seek it. Hemmed in by two magnificent rivers, it can grow but in one direction, and now this growth is taking place so rapidly, as to separate by miles the living and business portion of the community, making the problem of frequent and rapid intercourse an exceedingly difficult one. While this is being worked out and is soon to be demonstrated experimentally by Mr. Harvey's elevated railroad in Greenwich Street, attention ought to be turned to remodeling the pier and warehouse system. A long shore line of at least ten miles, is indented irregularly by piers of varying length, built always on timber piles, capped and planked in the cheapest possible manner. The shore bulk-heads are almost invariably a cribbing of square or round timber, filled in with stones. The surface of these piers is wasted, so far as storage purposes are concerned, being given up entirely to drayage and carting. The immense amount of handling thus necessitated, in distributing goods to warehouses in every inconvenient locality, makes the handling of freight in this city a matter of immense expense. It costs as much, if not more, to transfer a barrel of flour in New York, as to bring it nearly three thousand miles, from Chicago. The accompanying sketch may be taken as the standard method of constructing piers and docks in this city.



Glancing at material and construction, it will be seen that it does not take them long to become rotten and dangerous, to say nothing of the industrious little "terredo." Occasionally a cart disappears

through some decaying plank, or the piles separate from the framing through uneven settling, which is a signal for a few plank and spikes to cover up the "holes" with, a mode of repair that is in great repute with the New York dock builders, and their economical (?) employers.

Just fancy an Englishman gazing upon such docks for the first time, on arriving in New York harbor, having just left those grand imperishable stone and iron piers of Liverpool and London. Docks, too, covered with a complete system of fire-proof warehouses, furnished with every facility of steam-power. Such docks are really open ground floors, as it were, of the buildings overhead, and such construction is what New York must come to sooner or later. What is needed now to start it is, for the Legislature to appoint a Commission of competent men, to determine upon the future construction of docks and piers, and then make every addition to our wharfage improvement bend to the plan agreed upon. Instead of repairing old docks from time to time, as now done, tear them out root and branch, replacing with permanent structures, and all such piers should be so contrived as to allow of fire-proof buildings being built upon them for storage and such like, to be built from time to time as convenience might demand.

In this way New York may eventually work up to commercial facilities that she may well be proud of, and which will comport more harmoniously with the many public works which now do her so much credit. Truthful historian as Dietrich Knickerbocker was, he strangely omitted to describe the infancy of New York pier construction. I think that I am not far wrong in supposing that Hendrick Hudson and his jolly crew gave the hint on their first landing on Manhattan Island. I might in this place give a modicum of praise to the efforts of certain parties, who endeavored, under the caption of the "New York Pier and Warehousing Company," to have passed at Albany last winter, a bill authorizing them to construct permanent piers and fire-proof warehouses. These piers were to be constructed upon hollow iron piles, filled in with concrete and framed together by iron girders and beams. The buildings were to be three or four stories high over the piers, and to be furnished with derricks, grain elevators and all the conveniences required.

This bill failed to pass, on the only ground that prevents any other bill from passing, viz: shallowness of the pockets of the projectors. Just fancy a *belt line* of elevated railroad, skirting the bulk-heads of such piers, and throwing off sidings into the second floors of the warehouses. The cost of transferring freight around the city would

amount to a mere song, and it could be all done so rapidly and quietly as to be going on almost unobserved. When New Yorkers are worked up to such a scheme, they will invite freights through the inexpensive handling—freights that probably give the Metropolis the go-bye under other circumstances, seeking a cheaper outlet. All these changes we shall see, and that too before very many years roll over, for New York city has gone so far in her commercial importance and greatness that she cannot stop, and the brilliant future that awaits her, so soon as the country settles into its accustomed channels, will call out our best engineering talent, and she will yet show the world a system of harbor improvements, better than any that have gone before. Van Nostrand has just published a handsome volume (in press when I last wrote) on the Brooklyn Water Works, giving a complete history of its inception, development and construction, with accurate scale drawings of water supply, pumping engines and pipes adopted. Annexed to it is an interesting report of competent parties who were appointed to investigate the respective merits and economies of the various styles of engines. To the hydraulic engineer it is a work of great value. The style in which it is gotten up reflects great credit upon the enterprising publisher, and it is fully equal to the best English works of that character.

The grand exhibition of the American Institute, will take place the 12th of September, lasting until the 26th day of October. They are liberal in their call for American industry to put forth its best examples, and every effort is being made to eclipse all the former exhibitions. Of course, the usual awards in the shape of medals and diplomas will be granted freely. This granting of medals and the like, has become so common of late, that little value is attached to them by the public at large, and I trust that the Trustees of the Institute, at this coming exhibition, will be so judicious in their distribution of rewards, that when a medal or diploma is granted, it will be for a real and not a fancied improvement.

The classification of articles on exhibition will develop seven departments. Each department in turn will be divided into seven groups. The departments are—1st. Fine Arts and Education; 2d. Of the Dwelling; 3d. Of Dress and Handicraft; 4th. Chemistry and Mineralogy; 5th. Engines and Machinery; 6th. Department of Intercommunication; 7th. Department of Agriculture and Horticulture. The exhibition will be held in the armory of the Twenty-second Regiment, and when it comes a description of all matter of interest will be sent the *Journal*.

A. P. B.

Civil and Mechanical Engineering.

(Continued from page 27.)

THE NEW YORK "CENTRAL PARK."

By WILLIAM H. GRANT, Superintending Engineer.

CHAPTER IV.

SUPERSTRUCTURE OF ROADS CONTINUED—GRAVEL ROADS.

Two different methods employed in constructing gravel roads—1st. Roads with paved (Telford) foundations. Gravel; its desirable qualities. Samples of gravel obtained from the surrounding country. Pit-gravel and sea-shore gravel. Binding material. Failure in the trial of sea-shore gravel. Recapitulation of the qualities of gravel. Treatment of gravel on the roads. Screened gravel used. How binding material was applied. Shaping and rolling road. Failure to pack gravel without binding material. Evidence developed from year to year of the qualities of gravel road. Superiority of screened gravel road; its striking economy. Analysis of screened gravel roads, and of broken stone road. Gravel road for common roads.

The larger portion of the carriage roads of the Central Park—embracing all that has been constructed since 1861—is of the kind designated as *gravel road.* Two different methods were resorted to in the construction of this kind of road.

The first is a modification of the Telford plan, retaining the sub-pavement, which is the essential feature of that plan, and substituting a covering of gravel in the place of the broken stones.

The second method dispenses with the pavement, a stone bottom being formed of rubble stones (Plate II.) deposited on the road-bed with merely sufficient regulating and adjusting by hand to give them tolerable compactness and an even surface, and the finishing layer of gravel, as in the other case, being placed on top. The layer of rubble had about the same depth as was given to the pavement.

The first plan, with Telford pavement, has been mentioned as the one that was recommended for the Park roads at the commencement of the work, a sample of which was at that time built.

This plan was subsequently adopted and the roads were prosecuted in accordance with it, until, for the purpose of reducing the cost of the work, the later modification was tried, dispensing with the pave-

ment and using in its place the rubble stone bottoming. The special characteristics and details of construction of these two different kinds of road will be described in their order, commencing with—

1*st. The Telford Road with Gravel Foundation.*

The pavement for this road was constructed in all respects the same as has been described for the Telford road. It will also be understood that all the work of preparation, drainage, &c., up to the point at which the pavement was completed, was the same as for that road. In this case, therefore, the distinctive feature of the work consisted wholly of *the gravel and its manipulation.*

The questions to be considered as to this material, were its qualities, degrees of coarseness, color, where to be obtained, whether from inland or from the sea-shore, and how to be obtained in sufficient quantity and at a proper cost, for the purpose; also, how to treat it when applied to the road, to compact it and produce a firm, smooth and unyielding surface.

The first step in pursuing these investigations was to procure samples of gravel from all available localities of the surrounding country that were within reach, by such means and distances of transportation as were not too expensive. Numerous samples were accordingly obtained, presenting a great variety of material; some from the sea-shore, some from inland, some good and much that was bad, possessing nearly all shades of color and degrees of hardness and other properties. The rivalry and competition between different parties who became interested in the research, exhausted the field within, and considerably beyond, practicable distances from the Park. No available deposit of gravel, it is believed, within fifty miles of the city of New York escaped examination and a representation among the samples collected. Some samples were brought from nearly a hundred miles distant. The process of collecting the samples extended through several months, commencing before the general plan of gravel roads had been adopted, and continuing for some length of time after the work had been commenced.

The information that was thus very thoroughly obtained, upon the subject of the gravel, was not sought merely with reference to the roads, but was desired with reference to the walks of the Park also, and a greater variety of samples and qualities of gravel were examined for that object than would have been necessary for the roads alone.

For the purposes of the roads but few samples were obtained that were found worthy of attention. The important requisite of *hardness* was confined principally to such as were taken from the sea-shore, but the pebbles of this kind of gravel are so rounded and smoothed by attrition as to render them incapable of packing and consolidating on the roads without too great an intermixture of some inferior and deleterious binding material. The color of this gravel is also regarded as an objection, being mostly white, or of a very light shade; but this would not be insuperable if the gravel were desirable in other respects, inasmuch as the disagreeable glare to the eye that is caused by such gravel when used on walks, wears away in a measure, or becomes neutralized after a while upon roads. The pebbles, which are of quartz or silicious stone, are devoid of the quality of toughness, are too brittle and too easily crushed for good service. This gravel, however, possesses the advantage of cleanliness which is rare in other kinds, the attrition it has been subjected to having worn away the softer varieties of stone that may have been originally intermixed with it, and the action of the water having removed the disintegrated particles, together with all lighter or earthy matter. It is for this reason, suitable to be employed as an ingredient in concrete; but as a road material it is not desirable.

The gravel that was obtained from inland localities, or from deposits that have not been subjected to the action of running water, commonly termed pit-gravel, was found mostly to have been derived from the inferior rock, as sand-stones, slates, micaceous gniess, &c., and was consequently soft or friable, very unequal in texture and contained a large proportion of sand, together with dirt and vegetable matter. Some samples that were intermixed with harder gravel, that could have been profitably used if separated, contained so large a proportion of fine gravel and inferior material that it was impracticable, on account of waste and the expense of screening, to make it available.

The unevenness of the size of the pebbles and the disproportion that prevailed between what was really gravel, such as was demanded, and what was sand and dirt, was the general fault of the pit-gravel.

From this it will be seen that it was difficult to obtain such gravel as was wanted. The requisites that were sought and that were held to be of the first importance, viz: that the gravel should be hard, coarse, even and clean, and not water-worn, could not all be found combined in the same material.

The best that could be done was to select from among the different localities that were developed, the one that would furnish gravel containing in the greatest degree the requisites desired. In making this selection the mere samples of gravel were not trusted to as affording a test. Considerable quantities of different kinds of gravel were tried in actual use, on both roads and walks, and a close examination was given to the results of rolling, packing and wear, and to the effects of the weather—rain and frost. The cost of screening, and the amount of the resulting waste, and other facts, drawn from experiment, use or analysis, were ascertained and considered before an ultimate decision was arrived at. As regards the gravel that was used in the walks, these tests will be further mentioned when treating of that part of the subject. In the case of the road, the selection was made upon somewhat different grounds from those that governed in regard to the walks, and the decision finally settled upon the choice of gravel from a large deposit on the east bank of the Hudson River, at Royer Hook, near the village of Peekskill. This gravel was found to be hard and unusually clean, and portions of it, in some parts of the bed, of a nearly desirable uniformity as to size. The pebbles, although somewhat rounded, were not water-worn and polished as in the case of beach gravel. The color, a bluish grey, was about what was desired.

It was found, in applying it to the roads, that, unlike most other kinds of pit-gravel that were tested, its freedom from earthy impurities prevented it from packing properly under the roller, and that it required for this purpose, an intermixture of twenty to twenty-five per cent. of inferior material, to give it the necessary binding effect. This proved to be a clear advantage rather than otherwise, inasmuch as binding material from extraneous sources could be obtained at much less cost than gravel, and it was found that it could also be selected of better quality when foreign to the gravel than when it was contained in it.

The material desired was not generally difficult to obtain. This was a sandy and clayey loam. It was not found necessary to apply it to all the gravel—only to the surface of the last or top layer of the road.

Experiments were tried with sea-beach gravel, but it was found very much as was anticipated, that in its ordinary state it possessed no binding properties, and that no amount of rolling would pack it so that it would retain a firm surface upon the road after it became

dry. It was necessary to intermix it so largely with binding material in order to pack it, as to destroy the character of the road as a gravel road, by impairing the hardness of the surface.

In one instance, when this kind of gravel was used to complete a short piece of road, the supply of other gravel having failed for the time, it became necessary, from its impracticable nature, to subsequently remove it and replace it with the better gravel.

So much is found to depend upon the quality of the gravel in the successful formation of a gravel road, that it is a matter that cannot be too clearly and distinctly kept in view. In closing this part of the subject, therefore, a recapitulation is presented of the essential characteristics of the material.

First. It must be hard and tough, or the action of wheels and steel-shod hoofs, combined with the disintegrating effects of the weather, rain, heat, and frost, will soon pulverize it and convert it into dust or mud.

Second. It must be coarse and measurably even in size—coarse, to give it strength to resist the necessary service—even, to enable it to form a proper surface and to wear equally.

Third. It must be clean—all impurities impair its value, affect the hardness of the surface of the road, cause dust and mud, retain moisture and add force to the action of frost. The least quantity only of inferior material necessary to bind the surface should be used.

Fourth. It should not be water-worn, or at least it should not be of the kind—found on or near the sea-shore—that has been *very much* water-worn, rounded and polished, as such gravel cannot be packed without the interposition of so much inferior material as to destroy its essential characteristics on the surface of a road.

Besides these points, *sameness of texture or an even degree of hardness* in the separate pebbles, may be mentioned as necessary to produce a uniformity of wear of the surface. The color, also, is of some importance, dark shades being preferred to light ones.

It is, of course, impossible to find gravel combining in its ordinary state all these advantages. If it contain, in any considerable proportion, pebbles that are *hard* and *coarse*, to begin with, the requisites of evenness of size and cleanliness may be added by screening out the finer portions and dirt. This process is expensive and wasteful, and is to be avoided if practicable. It will be better, however, to incur the expense and waste than to use improper materials and hazard the character and *real economy* of the work.

In proceeding with the construction of the road, the gravel was deposited upon the prepared pavement, generally in two successive layers, making together, when completed and fully compacted, a depth of four to six inches; the depth was not less than five inches in the middle of the road, and not less than four inches at the sides. The first layer was composed of coarse gravel, in its natural state, as it came from the gravel bed. As the gravel was clean, and the finer portion constituted but a small part of the bulk, it was not considered necessary to screen it for the bottom layer. It was deposited at first by wheel-barrows, until a sufficient breadth was formed to drive wagons on, and then it was deposited by wagons driving over the layer and backing up so as to discharge their loads without permitting the wheels to come in contact with the pavement.

This layer was adjusted by raking it over evenly, and then rolled down with the lighter two-horse rollers. It was kept properly tempered by moistening—neither too wet nor too dry—by means of sprinkling carts, or by the use of hose attached to the road hydrants (when these had become available), while the rolling was going on, and was firmly compacted, so as to resist indentation by the horses' feet, before adding the next layer.

The gravel for the second or top layer was screened; the pebbles from about one and a half inches down to about three-fourths of an inch, the largest way, being separated from the finer material, and applied to the road (the finer portion being reserved for use in the walks, for which it was found to be well adapted.)

In the process of screening, a considerable quantity of pebbles or small stones, above the size desired for the roads, was obtained, which was usefully employed in making gutters to the walks, where required.

The method that was adopted in screening the gravel will be described hereafter.

The screened gravel was spread over the bottom layer, and after raking and adjusting it to an even surface the binding material was added. This material was chiefly obtained from the Park excavations below the surface-soil, and was composed of sand and gravel intermixed with loam and clay—not very dissimilar to the material known as hard-pan. Hard-pan itself (indurated sand and clay) was selected as preferable, whenever it was available without excavating it specially for the purpose.

This was spread over the gravel, forming a light coating, not

exceeding an inch in depth, care being taken to spread it evenly and to pulverize all lumps; it was then properly moistened by sprinkling, and rolled—first with the light rollers and next and finally with the heavy roller.

The sprinkling and tempering of the gravel was carefully attended to while the rolling was going on, not allowing it to become too dry or too wet, as in either case the rolling could not be done effectively. No rolling was permitted after a drenching rain until the gravel had had time to dry out; and in case of a rain of such duration as to affect the road-bed below the pavement, the rolling was suspended until such time as the operation of the drains had fully and securely restored the ground to a firm condition. Any disturbance or unequal yielding of the pavement, that would have been liable to occur by the premature use of the heavy roller, at such a time, would have been detrimental, if not fatal, to the work.

Men were kept in attendance who were skilled in raking and shaping the road surface, to keep it true to the required contour or crowning form, transversely, and to the correct grades-line, longitudinally of the road.

By the repeated sprinkling, raking and rolling, the binding material spread over the surface was worked down into the gravel to the depth of two to three inches, filling all interstices and surrounding the pebbles so as to hold them tightly in their places, and forming a firm, even surface, and one that was nearly impervious to water.

The rolling was thoroughly done, every part of the road being passed over from eighty to a hundred times, subjecting the gravel at all points to a pressure, in the aggregate, (the weight of the roller being about six and a half tons,) of five hundred to six hundred tons. The effect of this was a very complete consolidation of the material. Very little of the screened gravel was crushed in the operation, the hardness, size and shape of the pebbles protecting them from that result. The gravel and coarser sand, contained in the binding material, were to some extent ground up and the particles forced into the interstices between the pebbles.

When the road was finished the surface presented a sandy or earthy appearance, as was previously remarked in the case of the broken stone roads, the gravel not distinctly showing until after the road had been a short time in use, or after a rain.

It should be observed, in regard to the rolling, that attention was first given to the rolling of the gravel along the sides of the road

adjoining the gutters (the gutters having been previously laid), in order to counteract a tendency of the gravel, if first rolled in the middle of the road, to work off in a lateral direction.

It is also worthy of note, that in the construction of the original sample of gravel road, the experiment was tried of compacting the gravel (which was not screened) without intermixture with other substances. The result was similar to that in the case of the broken stone roads, in which the attempt was made to consolidate the stone without the aid of binding material. The gravel would pack well under the roller, and retain its firmness, so long as it retained its moisture; but when it became dry it lost all cohesion.

The material first resorted to, for binding purposes, was the detritus and scrapings that were left after the removal of the heaps of MacAdam stones from the places where they had been broken. This answered a very good purpose, but the supply was too limited for general use.

Lime-stone chips (refuse from lime kiln quarries) were next tried with successful binding results; but the great care that is necessary in using this material, and the difficulty of procuring it in proper condition, render its employment next to impracticable. It is liable also, if used in excess, to produce, in dry weather, a very disagreeable impalpable dust; and in wet weather, an equally disagreeable tenacious mud, these difficulties being inherent to all lime-stone roads.

The material that was finally resorted to, as previously mentioned, is regarded, upon the whole, as the best and safest kind for binding purposes that is generally available.

(To be continued.)

From the London Mechanics' Magazine, May, 1867.

HARBOR BUILDING WITH ARTIFICIAL STONE.

The substitution of artificial composite blocks for quarry-hewn stones has met with much greater favor, and is much more extensively employed, in France and on the continent than in England. The French have always been addicted to the use of concrete, béton and pierre perdue, to a much greater extent than ourselves—in fact, these materials form a very important item in the construction of all their harbor and marine works. Recently, at the works of the new harbor at Brest, denominated "Port Napoleon," these artificial blocks have been manufactured on a stupendous scale, containing individu-

ally over 50 cube yards of materials, and weighing above 120 tons. They are constructed upon timber platforms covered with a thin coating or layer of clean sand. The first specimens were provided with external grooves for the purpose of raising them by the aid of chains, but this method involves so much trouble and risk that it was speedily abandoned, and another plan adopted. It consists in bedding four rectangular pieces of timber, about two feet square and four inches thick, within the block near the corners, and placing them at a depth of one foot above the bottom, that is, the under surface of the timber is one foot from the lower external surface of the block. When this latter is completed, four vertical holes or sits, five inches by one foot four inches, are bored down from the top to the timber and continued through it for the purpose of inserting iron suspension pivots to which iron lifting rods are attached. One great advantage of this plan of raising is, that, when necessary, as it sometimes is, the blocks can be taken up again after they have been actually placed in position, an operation impossible to accomplish with the lifting chains. The blocks are composed of rubble stone, Portland cement, and sand, the proportions of the two latter being nearly four to one. Great care and attention is bestowed upon the manufacture, and the quoins are dressed and chamfered in order to insure close joints and a good fit between the contiguous blocks when deposited. A large number of blocks were put together upon the open strand by tidal work, as it is called, but so great a loss of time and material was incurred by this troublesome and intermittent process of manufacture that it became evident it would be more economical to construct them altogether out of reach of water and its destructive influence. Accordingly, a slip three hundred and seventy-five feet in length was prepared, with an inclination of one in sixteen, upon which were placed the movable platforms carrying the artificial blocks. These latter being completed, the platforms are drawn down the slip by an endless chain arrangement, set in motion by steam power. So soon as the block has descended to the required depth it is seized by a crane; the platform, relieved of the weight, immediately floats upon the surface of the water, and is easily drawn up again upon the slip. About thirty blocks, with their separate platforms, can be accommodated at the same time upon the slip.

As it is frequently an important consideration to be able to build a slip for temporary purposes wherever any work is carried on near rivers and coasts, unprovided with facilities of this nature, we give a description of the one alluded to. Strong square upright piers of masonry are built as the foundations proper; upon the tops of them, which are at different levels to suit the slope, are fixed three longitudinal balks seven feet six inches apart from centre to centre, and with their upper surfaces slightly cambered. The frame or box in which the blocks are manufactured is a strong timber construction, and rests upon the three longitudinal balks, the outer two of which are furnished with little rollers carrying the endless chain mentioned,

which is connected also with the barrel of a large winch. It sometimes happens that, notwithstanding the surfaces of the balks are always kept well lubricated, the platforms or cradles stick, and it then becomes necessary to start them from behind, which is accomplished by a lever. The chief point to be attended to in putting together slips of a temporary character is, that the foundation should be as immoveable as the nature of the ground will allow, or otherwise, the motion of any heavy weight upon them will cause an unequal settlement and the transit of the load is sure to be impeded, and every practical man knows the trouble and difficulty experienced in getting a fresh start. Having made the blocks and run them down on their cradles to the required distance, the final and most interesting part of the work is the operation of depositing them in their permanent position. A floating frame, partly of iron and partly of timber, is first constructed, supporting at the four corners an equal number of winches, to which are attached the suspension chains, carrying at their lower extremity the iron rods described at the commencement of the present article. The winches employed have a double purchase, and are worked each by four men. When this floating frame is supplied with all the necessary apparatus and gear, it is hauled, during a high tide, exactly over the block to be transported to its site. So soon as it is fairly over it, the four rods are passed through the holes bored in the block previously, a half turn is given to them, a small washer slipped upon each to make all secure, and the suspension chains hauled taut by the crabs. The tide continuing to rise, the frame becomes immersed, until, according to the law of hydraulic equilibrium, a portion of it is sunk sufficiently deep to raise the block from its bearings upon the platform. This separation being effected, the frame, together with the block, is towed to its destined site, and there made fast by means of buoys and guide lines established in connection with the shore. The foregoing operations recall, on a much smaller scale, those so successfully carried out in the floating of the Brittania tubes to the base of the piers and abutments they now occupy with so much utility to the public, and with so much credit and honor to all concerned in placing them there. The block being fixed exactly over its future bed, all that remains is to lower it accurately and safely down through the intervening water. Before commencing this process the tide is allowed to run out until the water is sufficiently low to permit the position of the blocks previously deposited to be ascertained. This is done by means of an iron rod, and the four crabs are then set in motion, and their burden lowered slowly and carefully to its final resting-place. If, as sometimes occurs, this is not accomplished correctly at the first descent, the block is raised again and its position accurately adjusted. After a little practice, the operation is conducted with remarkable regularity and certainty, the blocks are superimposed one upon the other with the most exact precision, and it is very seldom that a second trial is required. About fifteen days in the month are unavailable

for the actual deposition of these artificial blocks of masonry, but all other operations can, of course, be conducted without any intermission. By carrying on the work night and day, thirty blocks can be sunk per month, and the foundations of quay walls got in at the rate of one hundred and fifty feet during the same period. It is manifest that this system could be applied to blocks even on a much larger scale than that described, and with great advantage in hydraulic works of every description, and in fact, in all those whose strength lies in the innate mass and stability of the component parts.

From the London Engineering, July, 1867, p. 25.

SUSPENSION BRIDGES.

THE practice of American engineers, in respect of suspension bridges, is remarkable for its boldness, and in some instances for its success. The widest span yet reached in England, is that of seven hundred and three feet, at Clifton, for roadway traffic only, and this is formed of the heavy chains which once carried the footway of Hungerford-bridge, in a span of six hundred and seventy-six feet, with two side spans, across the Thames. The Americans have their double-floor railway bridge of eight hundred and twenty-two feet clear span, at Niagara, already in use for the last twelve years. On the other hand, a span of nine hundred feet over the Ohio river at Wheeling, and another of one thousand and forty-three feet, over the Niagara river at Lewistown, have been blown down in heavy gales. It is clear, however, that it was not merely the span, but the construction of these bridges which caused their failure.

The largest existing span of a suspension bridge is that of one thousand and fifty-seven feet, over the Ohio river at Cincinnati, lately completed from the plans of Mr. John A. Roebling, and under the superintendence of his son, Colonel Washington A. Roebling. Of this bridge, which is undoubtedly the finest work, structurally and architecturally, of its class, we shall soon give an engraving. It crosses the Ohio with a clear headway of one hundred feet above low water, the greatest variation between spring freshes and summer low level being sixty feet. The towers, of massive masonry, rise two hundred feet above low water. The supporting members of this bridge are two cables of parallel wires, of No. 9 gauge, drawn by Messrs. Richard Johnson and Nephew, of Manchester, each cable being twelve and a half inches in diameter, and containing five thousand two hundred and fifty wires, the breaking strength of the wire being upwards of sixty tons per square inch of net section. A large portion, nearly half, of the weight of the roadway and load is carried by diagonal wires, running straight from the tops of the towers to successive points along the floor, so that the main cables themselves stiffened by this arrangement, really carry but about half

of the total weight of the roadway and load. The ultimate strength of the bridge is very greatly in excess of the greatest probable, if not possible, load.

Having completed this work, Mr. Roebling is about to undertake one of far greater magnitude, that for connecting the city of New York with Brooklyn, across the East river. It is necessary, here, that a headway of one hundred and thirty feet be maintained in mid-channel, and the great suspension span will be one thousand six hundred feet in the clear, or much more than twice that at Clifton, nearly three times that of the Menai suspension bridge, and nearly six times that of either span of Lambeth suspension bridge. This great opening will be approached, on either side, by a succession of arches, the whole length being between one and a half and two miles, and the total estimated expense is six million dollars, or, at the present value of American currency, nearly one million sterling.

The cables will be four in number, fourteen inches each in diameter, and formed of No. 9 wire. The cables will be arranged one at each outer side of the platform, and two near the centre, the whole width of the platform being eighty feet. The platform will have six wrought iron trusses, each ten feet deep, for its whole length. There will be a footway, ten feet wide, along the centre, a horse railway on each side, occupying, each, sixteen feet, and a roadway on each outside of the platform, also sixteen feet wide, with a projection of the cross-beams of three feet on each side, to receive the connections from the outer cables.

As various and conflicting accounts of this undertaking have appeared, we may note that the details now given have been supplied by Colonel Washington A. Roebling, who is now in London, and who, we trust, before his return in January next, will read a paper at the Institution of Civil Engineers, upon the great suspension bridges executed and in hand by his father in America.

The towers of the New York and Brooklyn bridge will be of granite, three hundred and fifty feet high, and will measure one hundred and fifty feet by ninety feet at their base. The openings for the railways will be Gothic arches, one hundred feet high in the clear. The railway carriages ought, perhaps, to be described as tramway carriages, since they are not those of which ordinary railway trains will be made up. They will be of usual size, seating one hundred passengers each, and will be drawn across by wire ropes, working over drums at each end, the latter driven by fixed engines.

As a whole, no work of the same character, yet executed, approaches this in magnitude. It will undoubtedly be the crowning work of Mr. Roebling's life, and we may, not unreasonably, conclude that it will hand his name down to posterity as one of the greatest engineers of modern times. The difficulties of suspension bridge construction are not in general design, but in execution, and the history of the Cincinnati bridge, which will yet be written, will furnish a most interesting chapter in point, while that of the New York bridge will possibly far surpass it.

From the London Artizan, June, 1867.

COMPARATIVE STRENGTH OF LONG AND SHORT STRUTS.

By JAMES MACCALLUM.

THIS method of finding the strengths of long struts is but the geometrical expression of the principle first suggested by Tredgold, applied by Gordon, and elaborated by Rankine, viz: that in a strut one part of the greatest stress is that due to the direct crushing uniformly distributed over the cross-section, while the remainder is due to the bending action produced by the strut diverging laterally, thus relieving the crushing force on one side, and intensifying it on the opposite side. The formulæ, to which the application of this principle leads, although not complex, are found irksome in practice, more especially in the designing of struts, as the method of trial and error (which has to be used) involves the necessity of making the calculations two or three times over; and, besides, considerable care has to be taken in giving the proper values to the different quantities which enter into the calculation. It was the meeting with such trivial difficulties which first suggested the method given below, but perhaps its greatest use is the assistance it gives in forming clear conceptions on the subject of resistance to crushing by bending.

The questions which are here solved graphically are:

(*a*) Given the length, breadth and sectional area of a long strut, what is the sectional area of a short strut, which would be of the same strength as the given long strut? And the sectional area thus found being multiplied by the crushing strength of the material (as found by experiment, and recorded in tables of strength), will give the crushing strength of the given long column.

(*b*) And conversely, in designing a strut of a given length, to withstand a given crushing load; that load divided by the crushing strength of each square inch (as given in tables), will be the sectional area required for a short strut; but what would be the necessary area for the long strut?

These are the qusstions which are to be answered; and, to begin with the case which is perhaps of most frequent occurrence, and which is also the simplest, viz: that of a solid cylindrical wrought iron rod; for example, let it be required to find the crushing load of a wrought iron rod five feet three inches long, and one inch and three-fourths diameter (see Fig. 3). Draw $\overline{o\,h}$ = one and three-fourths inches, at h erect a perpendicular whose length is the length of a rod (five feet three inches) to the scale of one-fourth inch to the foot, and along it make $\overline{o\,h}$ equal to the base; from the point thus found draw $\overline{h\,h'}$ perpendicular to the base, intersecting the latter in the point h'; then $\overline{o\,h'}$ is the diameter of a short rod of equal strength to the given long rod.

Constructions for finding the cross sections of short struts of the same strength as long struts, and *vice versa :*

In all the following constructions,

$\overline{ob} = b$ the breadth of section
$\overline{oh} = h$ the thickness of section
os and the area of the section.

} as marked on sections Nos. 1 to 9.

These three are the dimensions of the long strut.

$\overline{ob'} =$ the breadth of section
$\overline{oh'} =$ the thickness of section
$\overline{os'} \propto$ the area of section

} of the short strut of equal strength to the long strut.

L is found as directed on the back of scales A and B.

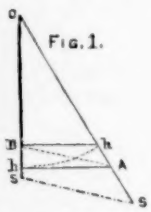
The data are drawn in light lines.

The results are drawn in heavy lines.

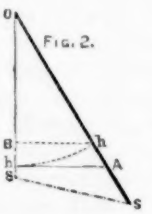
The lines of construction are dotted.

Two lines of construction which are parallel are distinguished by the same kind of dotted line.

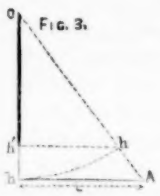
I. *Any form of Cross Section.* II. *Solid Square or Circular Sections.*



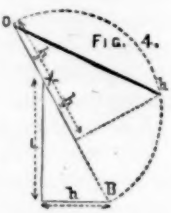
Given $h \times s$
Required s'



Given $h \times s'$
Required s



Given h
Required h'

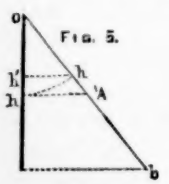


Given h'
Required h

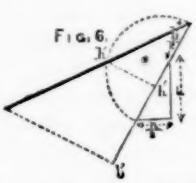
At the { ends / middle } the thickness may be made { h' / h }

N.B. The scale for solid circular cross sections is $\frac{1}{8}'' = 1$ ft. nearly.

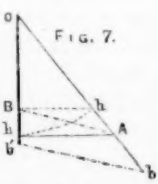
III. *Solid Rectangular Sections.* IV. *Solid Square or Rectangular Sections.*



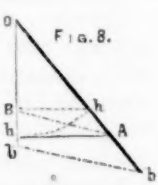
Given $b \times h$
Required $b' \times h'$



Given $b' \times h'$
Required $b \times h$



Given $h = h' \times b$
Required b'

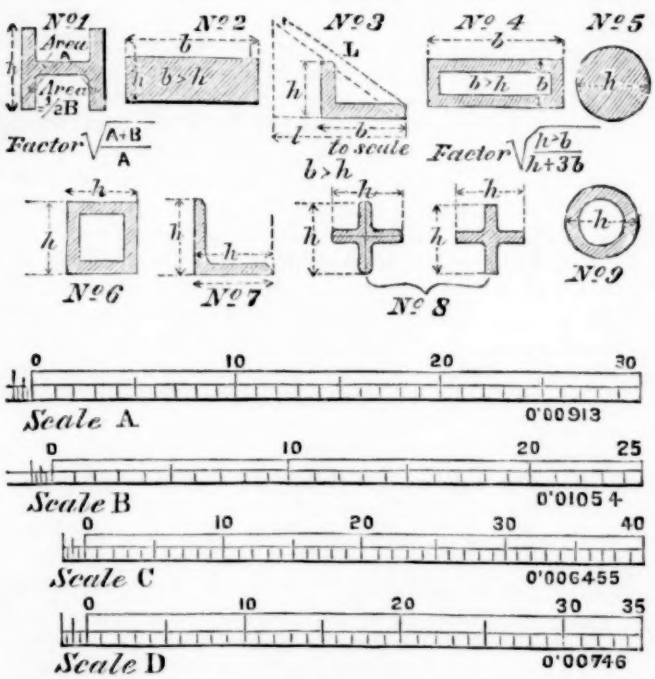


Given $h - h' \times b'$
Required b

At the { ends / middle } the cross sectional dimensions may be made { b' h' / b h }

In struts of uniform thickness h, the breadth at the { ends / middle } may be { b' / b }

This exemplifies the method of obtaining the strengths of struts whose dimensions are given, but the designing of struts of a given length, and to just withstand a given crushing load, is a somewhat more difficult problem. Let it be required to find the diameter of a cylindrical rod five feet three inches long, which will just crush with a given load. The required diameter of a short rod is readily found. Draw a straight line half the length of this diameter (see Fig. 4.); at one of its extremities erect a perpendicular equal to the length of rod drawn to the scale of one-eighth of an inch to the foot, draw the hypothenuse of the right-angled triangle, and produce it through the vertex to o, making the part so produced equal to half the given diameter of the short rod; along the hypothenuse from o (towards the vertex) lay off $o\,h'$ equal to the given diameter of the equivalent short rod; and upon the hypothenuse produced to o describe a semicircle. Lastly, at the point h' erect a perpendicular intersecting the semicircle; the length of the line joining that point with o will be the



required diameter of the rod. By the measurment, it is found to be exactly one inch and three-fourths. As there is no bending action at the ends, the diameter there might be one inch and a half, while the diameter at the middle remained one inch and three-fourths, or perhaps it would be more philosophical to make it rather more than one inch and three-fourths, to compensate for the slight diminution of

stiffness caused by turning off the metal at the ends; but, practically speaking, that extra metal adds little to the strength of the rod. The scale to which the length is set off is rather more than one-eighth of an inch to the foot, and is scale B of the accompanying set. But that part of the greatest stress which is due to bending, is affected by the form of cross section, and hence the necessity for using different scales for every different form of cross section. Thus scale A is suitable for solid, square, or rectangular sections; scale B for circular sections; scale C for thin, hollow, square sections; and scale D for thin, hollow, circular sections. Further, the method of demonstration indicated below shows that an L iron, say two feet long and three inches leaf, is just as much weakened by reason of its length as a thin hollow square strut one foot long and three inches square; hence the scale for the latter can be made use of for the former by simply doubling the length of strut. This shows the use to be made of the factors given on the scales.

The experiments of Mr. Hodgkinson have shown that if a strut be jointed at the ends (as in connecting rods), or otherwise so fixed that it is free to bend, its strength is the same as that of a short strut of half the length, firmly fixed in direction at each end; while a strut fixed in direction at one end only, and jointed at the other (or at all events free to move at that end), is of the same strength as a strut three-fourths of its length and fixed at each end. These scales being suitable for struts fixed at both ends, can be adapted to struts fixed at one end only, by multiplying the length by four-thirds, and to struts jointed at both end by multiplying by two.

When we have to deal with struts of other materials than wrought iron, we have little difficulty in adapting this method to our purpose. Experiment has shown that cast iron and timber struts are weakened by lengthening them somewhere between three or four times as much as wrought iron is weakened. The proportion adopted by Professor Gordon for cast iron is 3·35; that adopted by Professor Rankine for dry timber is 3·46.

The examples given in Articles 3 and 4 will sufficiently illustrate the other figures; but it may be added, that in finding the strengths of every kind of strut (except, perhaps, those of solid, square, or circular sections), whose dimensions are given, Fig. 1, will be found the most useful, while, in designing long struts, the whole of the figures 2, 4, 6, and 8, will be found of use. Fig. 6, although stated to be for solid rectangular sections, will be found useful in designing all irregular sections, such as L iron, H iron, &c., the precaution being taken to increase the thickness of metal in the same ratio that b' has been increased to b, and h' to h. But as this would often lead to uneven measurements, it has been found better in practice to use Fig. 6 as a guide to assist in fixing upon the transverse dimensions, verifying by Fig. 1.

We here omit the mathematical demonstration given by the author, which occupies more space than its interest to the majority of our readers would warrant us in giving to it.—*Ed. Jour. Fr. Ins.*

To find the length of the line L used in constructions:

1. Multiply the length of strut by the factor marked on the scale. (This is not required for the sections Nos. 2, 5, 6 and 9; section No. 3 will be considered separately.)

2. If the strut is of wrought iron, fixed at each end, pass on to (3); if not, convert the length found in (1) into the equivalent length of a similar wrought iron strut, fixed at each end, by means of the table below.

TABLE *for converting the lengths of struts into the equivalent lengths of wrought iron struts, fixed at each end.*

Wrought Iron.				Cast Iron.				Dry Timber.			
Both ends fixed.		One end fixed, other end jointed.		Both ends jointed.		Both ends fixed.		One end fixed, other end jointed.		Both ends jointed.	
ft.	in.	ft.	in.	ft.	in.	ft.	in.	ft.	in.	ft.	in.
	1		1½		2		3½		5		7
	2		3		4		6		10	1	1½
	3		4½		6		10	1	3	1	8
	4		6		8	1	1	1	8	2	2
	5		7½		10	1	4	2	1	2	9½
	6		9	1	0	1	8	2	6	3	4
	7		10½	1	2	1	11½	2	11	3	11
	8	1	0	1	4	2	2	3	4	4	5
	9	1	1½	1	6	2	6	3	9	5	0
	10	1	3	1	8	2	9	4	2	5	7
	11	1	4½	1	10	3	1	4	7	6	1½
1		1	6	2	0	3	4	5	0	6	8
2		3	0	4	0	6	8	10	0	13	5
3		4	6	6	0	10	0	15	1	20	1½
4		6	0	8	0	13	5	20	1	26	10
5		7	6	10	0	16	9	25	2	33	6
6		9	0	12	0	20	1	30	2	40	3
7		10	6	14	0	23	5	35	2	46	11½
8		12	0	16	0	26	10	40	3	53	8
9		13	6	18	0	30	2	45	5	60	4½
10		15	0	20	0	33	6	50	3	67	1
20		30	0	40	0	67	1	100	7	134	2
30		45	0	60	0	100	7	150	11	201	3
40		60	0	80	0	134	2	201	3	268	4
50		75	0	100	0	167	8	251	6	335	5
60		90	0	120	0	201	3	301	10	402	6
70		115	0	140	0	234	9	352	2	469	7
80		120	0	160	0	268	4	402	6	536	8
90		135	0	180	0	301	10	452	9	603	9
100		150	0	200	0	335	5	503	1	670	10

3. The length thus found, laid off to the proper scale, will be the length L to be used in the constructions.

Example.—A timber crane jib (and therefore jointed at both ends) is sixty-five feet four inches long; required the equivalent length of a wrought iron jib, fixed at each end.

ft.	in.	ft.	in.
60	0	415	8½
5	0	34	7½
0	4	2	3¾
65	4	452	7½

That is to say, that such a timber strut, sixty-five feet four inches long, would proportionally be as much weakened by reason of its length as a wrought iron column would be weakened of the same cross-section, four hundred and fifty-two feet seven inches and a half long, and firmly fixed at both ends.

To find L in the case of L irons with unequal leaves, proceed as follows (see diagram to section No. 3, scale A).

1. Multiply the length of strut by 1, 1½, or 2, according to the manner in which the ends of the strut are fixed; call the product *l*.

2. Find L as shown on the diagram.

CONVENTION OF ENGINEERS AT ST. LOUIS.

A convention of engineers, embracing some of the most famous in the country, assembled at St. Louis, August 22d, to consult in reference to constructing a bridge across the Mississippi River at that point, for the Illinois and St. Louis Bridge Company. I. Alpine was elected President; Thos. McKissock, Secretary. A committee on a plan of the foundations and piers of the superstructure was appointed, and with a number of citizens made an excursion up and down the harbor.

The bridge will be about 2000 feet long, of the truss pattern, with between 300 and 400 feet spans, 50 feet above high water mark. It will cross at a point near Carr Street. Another Company, called the St. Louis and Illinois Bridge Company, of which Captain James B. Eads is Chief Engineer, will build a bridge crossing at Washington Avenue, and have already collected considerable material on the river bank, ready to commence work as soon as the water becomes sufficiently low, when both these structures will be raised.

Mechanics, Physics and Chemistry.

(Continued from page 115.)

LECTURES ON VENTILATION.

Delivered before the Franklin Institute, by L. W. Leeds, Esq.

LECTURE III—Continued.

Thus you see, taking the air at 10° and heating up to 70°, the ordinary temperature of our rooms, requires about nine times the moistue contained in the original external atmosphere, and if heated to 100°, as most of our hot-air furnaces heat the air, it would require about twenty-three times the amount in the external atmosphere.

This is a very interesting and important subject, but I am sorry I have not time for further explanation.

Well, some kind friend has been around and opened the doors of our meeting-house and awakened the sleepers. And now you see the lights shine, and the cheeks glow as brightly as would those of our young ladies could they be persuaded to go skating, or take a five mile walk every day, rain or shine, and sleep with the windows open, and never ride in any of our cars, or go to parties or any other public gatherings unless the buildings where they were held were well ventilated.

But those dreadful drafts! People will not bear them. Let us see if we can accommodate them. Put on the roof, and here comes this dreadful current again down the ventilating flue. Well, ventilating flues have the name of being great humbugs. Let us shut them up. There are your poor consumptive patients—there they go, you see. One-half dead already, and the rest will soon follow if we cannot rescue them. Let us open the flue again. See how they brighten up as the fresh air comes in. Well, there is no use of disputing about it, you must have *a current of fresh air coming into your house* or you will surely die.

Now let us change the programme. Let us build a fire in this fire-place in the lower story—that burns up brightly. Where does it get fresh air from now? There can be no current down the chimney. Let us search it out with this smoking taper. Ah, here it is coming down through the ventilator from the very top of the house. We will soon stop that by this cap. Well, well, it still burns as brightly as

ever. Let us try again. Ah, do you see the smoke rushing down the second story chimney and across to the stairway, and down the stairs, and across the room again to this fire?

There is a valuable hint. Have you not noticed frequently gas in the room from the fire-place or stove, and especially at night? And do you see how easily it would be to account for it if the house was shut up tight at night, with a large fire in the kitchen or furnace in the cellar, and but a small fire in the second story? Don't you see how the whole products of combustion, all the poisonous gases, may be drawn out into the room? You often notice accounts of whole families being smothered to death in one night, but many seem to think if they are not smothered to death the first night, that it is not so very dangerous after all, and not knowing how to remedy it easily go on from day to day and sometimes escape the whole winter with a little of their lives left.

Now, let us put out the fire in the first story and make one in the second.

You must remember that this is not a fashionable double ceiled and plastered air-tight house. It is much more open, in proportion to its size, than any ordinary house. And now, as this lower flue has been so highly heated, it may take some time for the fire in the second story fire-place to become heated sufficiently in excess to cause the air to draw down the longest flue to the bottom of the house and up the stairs to the second story fire-place, but it will soon do it.

I wish you to notice one thing here particularly, and each one apply it to your own particular case. You know the lower part of the house is closed up tight to keep out the robbers, and if great care is not taken to give an abundant supply of fresh air to your chambers otherwise, it will be drawn up through the hall out of your kitchen and cellar, and as the cook has left the range lid off and shut the dampers, you will have a suffocating smell of gas all over the house. But the worst danger of all is the air that may be drawn in from an untrapped sewer or cesspool. This is a very common but great source of ill-health.

Sanitarians have given much attention to this subject lately, and have been astonished at the magnitude of the evil. I have long maintained that a family might go to the highest and most healthy location in the world, and by a little carelessness might accumulate sufficient filth around them, and by closing up the house at night and allowing

the foul gasses from untrapped sewers and cesspools to enter through the halls to their sleeping rooms, to thus make what would otherwise be a healthy place a very unhealthy one.

As a case in point, I would refer to a very interesting report of Doctors Palmer, Ford, and Earle, giving an account of their investigations of the causes of a severe epidemic that occurred in the summer of 1864 in a young ladies' seminary in Massachusetts. "The Maplewood Institute" is situated in Pittsfield, one of the most beautiful of those charming New England villages, which, to external appearances, are the very emblem of all that is pure and healthy. Yet even in this lovely place, from an ignorant or careless arrangement of the drains and cesspools, much of the foul gases generated there found its way into the building,* making sixty-six out of seventy-four young ladies sick, fifty-seven of whom had the typhoid fever and thirteen died. Many similar cases are frequently occurring, some few of which, like this, are carefully investigated, and the causes removed. Many more, however, go unnoticed, and are accepted as special dispensations of Providence, when it is all due to our own negligence.

I want to show you an arrangement that ought to be in every house. We have seen the power of a fire to create a draft, and if you will think a little you will notice that the kitchen fire is the most considerable and most prominent power in ordinary dwellings, and this ought to be made use of to ventilate the kitchen, water-closet and bath-room in every house. But you must not make an opening directly into the kitchen flue, if you do you will interfere with the draft of the kitchen fire, and if you interfere with the kitchen fire you will soon wish yourself at anything but keeping house.

But we can easily get over that trouble. We will use this square glass box again to represent a flue. I don't mean this to represent the size—it ought to be twice that size. In the centre we will put a cold pipe, to show you that a pipe without any heat in it would only cause the foul air to tumble down into the room. Thus you see the smoke descending. We will substitute a pipe with a gas light to heat it. Now you see what a rapid current there is out of this large flue. See what a splendid arrangement this is for ventilating, and it may be extended so as to ventilate the whole house. It is not necessary that

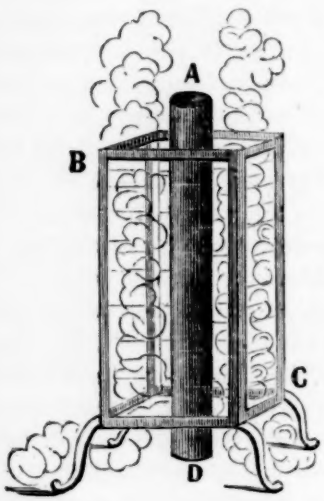
* In addition to which there appeared to be a deficiency in the arrangements for ventilation.

the room to be ventilated should be adjoining, but a pipe can be carried between the floors 50 or 100 feet.

I had an opportunity, during the late war, of thoroughly testing this system of ventilation in the government hospitals.

Let me say here, that a very common mistake in making ventilating flues is, that they are entirely too small to be of any value. One of these little Philadelphia flues, four by nine inches, made with rough bricks, and very nearly or entirely choaked up with mortar, as many of them are frequently found, is of no account. They are simply a deception, and a perfect provocation to a sensible man.

Fig. 15.



I commenced by making some in Washington, for single wards, thirty inches square; but in St. Louis, Louisville and Nashville, where buildings four or five stories high were used for hospitals, I made them much larger, some three feet square and some four feet by six feet. Some buildings, where the ventilation was so bad and the water-closets were so offensive that the government had to abandon them, I had ventilated by these immense shafts, heated by the kitchen and laundry fires, which proved thoroughly efficient and entirely satisfactory.

I had hoped to have time to discuss the subject of heating more fully in connection with ventilation, but cannot; but I will state, in the simplest manner, a few of the leading points first.

You must have fresh air all the time. In summer you can get it by opening the doors and windows. In winter it must be warmed before entering the room. It must not enter the room cold and flow across the floor to the other side before it reaches the heating apparatus. You can bear a large amount of fresh air if it strikes you in the face and evenly over the whole body, but never let a jet of cold air blow upon any small portion of your body.

To avoid these local currents sucking in at cracks, you must make provision for the introduction of an amount of air *larger* than the

sum of all these cracks, and your exhaust flue besides. This air must be partially warmed before entering. If this is done by a hot-air furnace, it must have a large fresh air box, which should be from eighteen inches to two feet for a large house. It should have a large evaporating vessel, with a ball-cock to supply it. You cannot get the servants to attend to it, and you must never allow the air from your cellar to enter your furnace to be driven up stairs. Never allow the furnace to get red-hot.

A hot water furnace disturbs the natural conditions of the air the least, and, on that account, is a very healthy means of artificially heating air. But they are necessarily expensive, and so few persons really appreciate the value of pure air, that but few will go to the expense of introducing them. It is a mistake to suppose that they do not dry the air, so to speak. You cannot elevate the temperature without increasing the capacity for moisture. A hot water furnace, therefore, requires the artificial evaporation of water to give the warmed air its true hygrometric condition.

Heating the air by steam is the next most healthy means; as the surfaces used are heated a little hotter, less of it answers the same purpose. The first cost is therefore less. It is the most rapid and convenient means of conveying heat to any distant point of anything now in use. Under the pressure of an ordinary boiler it will travel seven miles in one minute. The time I hope is not far distant when the subject of heating and ventilation will receive an amount of attention due to its importance. I believe then we shall have steam pipes laid through our streets, the same as gas and water now are. The present system of each man keeping up separate fires all over his house is as crude, and extravagant, and unnecessary as it would be for every man to make his own gas or have his own well for water.

Where a steam furnace is used, two-thirds of the heating surface should be put below the floor and fresh air brought into it, and from there conducted to the rooms through large pipes. This warmed air should be let into the room at the floor, and an opening into an exhaust flue, two-thirds the size of the inlet, should be provided at the floor for the escape of the foul air. The remaining one-third of the heating surface should be exposed in the halls and some in the other parts of the house. To heat by direct radiation, but under no circumstances should a room or office be occupied *heated exclusively by direct radiation* from exposed steam pipes. It is one of the worst, most unhealthy, *killing systems* in existence.

Steam furnaces require the evaporation of an additional amount of moisture as well as any other system of heating. According to Dr. Wetheral's investigation, it would require the evaporation on some days of nearly forty pounds of water every minute in the Senate Chamber to maintain the proper hygrometric condition. Probably one of the very best arrangements is to have a good steam furnace, with a large fresh air box letting in an abundance of air moderately warmed, and overflowing the house with this, and some direct radiation in the halls, and a good, bright, cheerful open fire in the family sitting-room.

But if you cannot have a steam or hot water furnace, you can make a room very comfortable indeed with a stove, if you will but introduce all the fresh air required for the room directly against or on top of the stove. No stove ought to be put up without having a supply of fresh air from the outside, and a large evaporating vessel, kept constantly filled with water, with an opening in the heated flue near the floor for the escape of the foul air.

In conclusion, allow me to urge upon you to examine your furnace this evening or to-morrow morning, and if there is no fresh air box communicating with the external atmosphere, go to the nearest carpenter's shop before going to your business, and get him to come at the earliest possible moment and put in a good large one, and if he asks you where you want the damper in the cold air box, tell him you don't want any.

Dampers in cold air boxes are handy things to have in the house, when used properly, but, like fire-arms, are very dangerous if you do not understand them. Yes, dampers in cold air boxes and other contrivances for keeping the fresh air out of houses, have killed more persons than all the fire-arms ever made in this country or any other.

If you have no evaporating vessel in the furnace, stop at your furnace man's, and tell him to put in two good large evaporating vessels in such a position that they will evaporate two or three buckets of water a day in cold weather.

And if you have a stove at your office, stop on your way down and buy a good large earthen pan to set on the top of the stove, and keep it always full of water. Make a pipe for the inlet of fresh air to every stove over which you have any control, and never remain in a room one day without a good opening at the floor for the escape of foul air.

And from my own experience, and that of many others whom I

know to have given much attention to this subject, I can assure you, with the fullest confidence, that you will be most amply rewarded for your care in this respect by increased health, strength, happiness and long life.

LECTURES ON MINERALOGY.

By Theodore D. Rand.

LECTURE II.

MINERALOGY AND GEOLOGY OF THE DISTRICT LYING NORTH AND NORTH-WEST OF PHILADELPHIA, NORTH AND EAST OF THE SCHULKILL.

North of Philadelphia, the west bank of the Delaware is skirted by a strip of alluvium of no great width. Back of this appear the primary rocks, rising gently to form a ridge or low table land, extending from near Trenton, past Philadelphia, into Delaware. On the west, these primary rocks are bounded by the limestone basin of Montgomery county, bordered by a long narrow ridge of very hard sandstone, with altered slates of the Potsdam period. This ridge makes its appearance in New Jersey, below Trenton, and runs south-westwardly past Barren Hill (where it is well exposed), almost to the Wissahiccon. The bold hills bordering this stream and the Schuylkill, are chiefly of gneiss and mica schist, the sandstone appearing at Spring Mills. The easternmost of these primary rocks appears to be true azoic gneiss, the westernmost probably altered shales, &c., of the Potsdam or lowest Silurian period, but so changed by the action of heat and pressure as to be unlike that formation where less disturbed, and closely to resemble the gneiss and mica schist of an older date.

The most interesting locality of this section is the quarry of Mr. George Van Arsdale, about three miles south of Attleboro', in Bucks county. It is situated in an isolated, very greatly metamorphosed bed of Trenton or Auroral limestone (the most eastern exposure of that formation), bounded by very hard hornblendic gneiss. The limestone is generally granular, very full of graphite, and contains, or has associated with it, many of the minerals for which the metamorphic limestone of New York is so famous, viz: Pyroxene, both crystallized and in its varieties of sahlite, fassaite and coccolite; sphene, sometimes very fine; green mica of unusually deep color; calc spar; wollastonite, in very beautiful specimens; a peculiar very glassy

feldspar—orthoclase—sometimes opalescent, and called labradorite, though it is not that species; phlogopite; blue quartz, probably the finest in the world; garnet; molybdenite; zircon, rare but in beautiful specimens; scapolite, variety ekebergite, and also crystallized; iron pyrites; beautiful specimens of the moroxite variety of phosphate of lime; graphite in very large plates, forming beautiful cabinet specimens. Except the lead mines of Phœnixville, this is the finest mineral locality near Philadelphia, and it is questionable whether anywhere so small an excavation has yielded so many species.

The limestone is much contorted, and veins or beds of hornblende mica, &c., of darker color, pervade it. The contortions have, in some cases, formed distinct letters of this darker rock, in the white limestone. Mr. Van Arsdale has an entire alphabet with few exceptions and many letters duplicated, so that he can spell several names. These letters are not indistinct, but exceedingly well formed and unmistakable. They are justly prized by their possessor as the greatest curiosity of his quarry.

At Frankford, quarries of considerable extent have been opened in hard hornblendic gneiss, forming an excellent building stone, but yielding little to the mineralogist, though occasionally very good stilbite may be procured, and traces of molybdenite.

Along the railroads passing through this section, the ballast gravel from the line of the Philadelphia and Trenton railroad, contains basanite—sometimes in very good specimens. In the gravel of this region a quartzose sand occurs, coated with oxides of iron, manganese and cobalt. An analysis gave—

Sand	95·40	Or the coating alone.	
Fe_2O_3	1·10	Fe_2O_3	28·05
CoO	·45	CoO	11·52
MnO_2	2·10	MnO_2	60·16
	99·05		99·73

Except at these two localities, the mineralogist will find little to interest him until he reaches the Wissahiccon. This stream, passing through the limestone and sandstone of Montgomery county, meets the ridge, of which mention has been made, at Chestnut Hill, and nearly at the line of the city, and flowing south-eastwardly through a narrow deep tortuous gorge, in a general direction nearly parallel with the Schuylkill, for a distance of about four miles, flows into the latter, about three miles from Fairmount.

Nowhere near Philadelphia can the gneiss and mica schist rocks be better studied than on the banks of this beautiful stream. Rising abruptly from each bank to a height of two hundred or three hundred feet, often precipitously, there are many exposures which will amply repay repeated visits and prolonged study. A very fine one may be found on the north bank, between Heft's mill and the oil mill, opposite Levering, Gorgas and Crease's lanes, which lead from the Ridge Turnpike to the Wissahiccon.

At McKinney's quarry, on Rittenhouse Lane, north-east of, and very near the creek, flesh-colored feldspar in large masses, containing enormous rough fragile crystals of apatite, was formerly abundant, but the vein has not recently been worked. Zeolites, however, chiefly stilbite and natrolite, in poor specimens, are abundant. Heulandite, epidote, crystallized hornblende, erubescite and malachite also occur.

Above this, near Heft's mill, alunogen occurs as an efflorescence, and on Crease's and Gorgas' lanes, tourmaline and kyanite in indifferent specimens, with now and then a crystal of staurotide and a loose mass of fine hornstone. Near Magarge's paper mill, staurotide is found in large but very rough crystals and rarely in the cross-shaped compound crystals so characteristic of the mineral. Specimens, showing the cross distinctly, and some quite smooth and perfect crystals, have been found. In small masses in quartz, or between the laminæ of mica schist, at different places in this vicinity, titanic iron occurs, but it is not common. All along the stream, however, from the Schuylkill to Chestnut Hill, garnets abound in the mica schist, but they are very rarely of any size or well crystallized.

At Chestnut Hill, a narrow belt of serpentine rocks crosses the stream and continues in a south-westerly course for about four miles, crossing the Schuylkill at the celebrated soapstone quarry. On the Wissahiccon the rocks present few features of interest, and contain no minerals, save a few crystals of magnetic iron.

At a small quarry between Magarge's mill and this belt, many of the rocks have a thin coating of hyalite. In the same vicinity, pale-brown crystals of apatite have been found and a greenish mica.

Nearly west-northwest from Chestnut Hill lies Barren Hill, a subordinate undulation of the range of which Chestnut Hill is a part, composed of altered sandstones, mica schist and gneiss of the Potsdam or earlier periods. At Barren Hill the sandstone has been converted into a hornstone, lying in nearly vertical layers, rarely more than a few inches, and often not more than a few lines, in thick-

ness. At a quarry on the turnpike, where it is well exposed, these layers are vertical, except near the top, where they are bent over into an almost horizontal direction, in a curious manner.

About three-quarters of a mile west of Barren Hill, at Marble Hall, is the remarkable marble quarry of D. O. Hitner, Esq. This bed of marble, an altered Auroral or Trenton limestone, devoid of fossils, is nearly perpendicular, dipping S. 20°, E. 85°. The quarry itself is about sixty feet wide at the top, probably four hundred feet long and nearly or quite three hundred feet deep. The average thickness of the bed of white marble, which is of very fine quality, is about eight feet, but in one place it widens to twenty. Near the bottom of the quarry the bed of marble bends almost horizontally to the south-southeast, some fifteen or twenty feet, then again resumes its original direction. A few arches of the marble have been left to prevent the falling of the overhanging side of this vast and dangerous looking chasm. Whatever the pleasure with which one may explore its depths, there is a great feeling of relief on safely emerging from it. A remarkable feature of this quarry is, that although so deep and in limestone rock, very little water occurs; a comparatively small pump keeps it always dry enough for convenient quarrying.

Except the marble, this quarry produces little of note to the mineralogist. Some twenty years ago a mass was detached and the usual hoisting apparatus applied, which gave way. It was repaired, but again the same result followed, when it was found that the mass was far heavier than the marble which they had supposed it to be, and from which it could not be told by the eye—it was sulphate of baryta or heavy spar, the specific gravity of which (4·3 to 4·7) is nearly double that of marble (2·5 to 2·7), so that while a cubic yard of the latter would weigh but about 4200 pounds, the same bulk of the former would weigh over 7500.

At Conshohocken and Spring Mills, towns a mile apart on the Schuylkill, about fifteen miles from Philadelphia, are five anthracite iron furnaces, for reducing the metal from its ores. These furnaces usually keep on hand large quantites of ores from the neighborhood, almost entirely brown hematite, and also frequently ores from a distance; the magnetic ore from Cornwall, in Lebanon county, Reading, French Creek, Chester county, and the Adirondack Mountains of New York; bog ore from New Jersey, &c.; so that at all times good specimens of many of these, and of the minerals associated with

them, may be obtained. As I have stated, the chief and almost the only ore of the neighborhood, is the brown hematite, found in very many localities, in beds or nests in a shaly, crumbling rock, or in gravel or clay, resting generally, if not always, upon limestone. Some of the specimens are remarkable for their fibrous structure and purity, but the ore at present used at the furnaces does not seem equal to that obtained five or ten years ago. The mines, if they may be dignified with the name, are, as a general rule, very shallow excavations—often only pits, sunken a few feet. The deposits seem rarely to have much depth, and are soon worked out. They are very numerous, however, so that in hundreds of places adjacent to the ridge of which mention has been made, but chiefly if not entirely over the limestone of the Montgomery valley, the brown dirt heaps of the miners may be seen. One of the finest mines is that of D. O. Hitner, Esq., lying just east of the ridge, five or six miles north-east from Spring Mills, and one mile west-northwest from Edge Hill Station, on the North Pennsylvania Railroad. Here the excavations are quite extensive, and the ore of remarkably fine quality. Much of it is in geodes, weighing from less than a pound to hundreds—forming what is known as bombshell ore. Those geodes often contain a beautiful velvety variety of brown hematite, sometimes in stalactites. More rarely, göthite or lepidocrokite, crystalline in structure, sometimes resembling the rubenglimmer, lines the geodes, forming unusually fine specimens of the mineral. Pyrolusite and wad are sometimes found. One specimen of the former was in delicate silky radiating fibres one-fourth of an inch in length, giving a plush-like appearance of unusual beauty. The cause of the velvety appearance of the brown hematite needs investigation. It disappears on the slightest touch, leaving a smooth glossy surface; but strange to say, nothing whatever appears to be removed by the touch,a piece of white paper or linen remaining unsullied, though removing what appears to be a coating.

Cacoxene, a rare mineral, a phosphate of alumina and iron, occurs in remarkably fine specimens in the hematite of this region. It is not common, however.

At Spring Mills is the western limit of the gneissic rocks, bounded by the altered sandstone ridge, of which mention has been made. The final ridge, partly gneiss and partly sand-stone, is of great elevation, and, jutting out as it does towards the river, affords to the lover of nature a panorama not exceeded by any view near Philadelphia,

except, perhaps, that from the Tower of the Water-works at Chestnut Hill, and in some respects it surpasses even that. It may be ascended directly behind the lower furnace, on the river bank, and will well repay the effort.

The minerals obtainable at these points may be enumerated as follows: Brown hematite; lepidockrokite; magnetic iron, crystallized, foliated, and massive; iron pyrites in fine octahedra; copper pyrites, sometimes in fine tetrahedral crystals; and also pseudomorphs, by alteration, of brown hematite, after tetrahedral copper pyrites; byssolite; calcite; bog iron ore; chrysocolla; malachite and more rarely, cacoxene, chalcedony, gibbsite and allophane. The byssolite occurs in cavities in the magnetic iron, and sometimes permeates calcite. At times the calcite is translucent, the byssolite being in small quantity. It then appears by transmitted light, full of the needles of the mineral, which may be completely exposed by hydrochloric acid, which dissolves the calcite, leaving the byssolite untouched. In some specimens the byssolite is so abundant that the calcite is almost without cleavage, and exceedingly tough.

At Conshohocken there is a large dyke of trap. It is well exposed at several points on both sides of the river, but best about an eighth of a mile east by north from the Norristown Railroad Station. This is probably the best exposure of trap near Philadelphia. North of Conshohocken, fibrous tourmaline and titanic iron occur in quartz; also a reddish quartz, slightly aventurine; and rarely phyllite in limestone.

Opposite Conshohocken, in the quarry of George Bullock, Esq., occurs a vein of crystallized calcite. Some of the crystals are unusually fine. They are hexagonal prisms, with the ordinary three terminal planes, sometimes *doubly terminated*, and perfect, sometimes the plane 1^3 very distinct, but rough. Crystals have been found over two inches long and an inch and three-quarters across. Arragonite also occurs as a coating on limestone.

I have previously spoken of the serpentine or steatitic belt, crossing the Wissahiccon, at Chestnut Hill. On the Schuylkill three quarries have been opened on a large bed of steatite, in this belt, the chief on the north-east bank. This has been largely quarried for nearly a century, having been extensively used many years ago for sills, door-steps, &c., owing to its being so easily worked; but as it is of very unequal hardness, it wears unevenly and soon becomes unsightly, so that for many years the former use of it has been abandoned, and it

has been quarried solely for use in furnaces, particularly reverberatory furnaces, for which purpose the consumption is very large. The quarry is entered from the side of a hill, and is about one hundred and fifty feet across, two hundred and fifty feet in horizontal depth and probably one hundred or two hundred and twenty in vertical depth, at the back. The stone is so soft that it is reduced to blocks of the required size by small picks and wedges, without blasting. The beds (for there are two), dip slightly to the north-west. The stone is removed as far as is thought safe; then a large blast is fired in the overhanging waste rock, causing immense masses to fall—sometimes hundreds of tons. These are blasted into smaller pieces and removed, when the quarrying proceeds as before. The rock is transported on sleds, the steatite making the road almost as slippery as if of ice. Many curious minerals occur in this quarry. Talc, often in masses of considerable size and fine color; dolomite in cleavable masses, and also fine granular; apatite; a curious variety of anthophyllite; sulphate of copper; erubescite; copper pyrites; epsom salts; a mineral resembling vermiculite, but which an imperfect analysis shows to contain an unusual amount of iron; magnetic iron in octahedral crystals; staurotide, in quite perfect crystals, naturally interrupted. These minerals occur not in the soapstone or steatite, but in the accompanying rocks; hence the quarries on the southwest bank, which are of less extent and almost entirely in the steatite itself, do not yield many specimens of value. Talc and asbestos occur near the quarry. On the north-east, iron garnets in immense quantities, but rough.

On the island formed by the canal, at Flat Rock, small quantities of a silicate of iron, apparently yenite, have been found in connection with a carbonate of lime and iron.

Along the Norristown Railroad, iron garnets are very abundant in mica schist, but in small and generally rough specimens.

From the London Engineering, June, 1867, page 671.

THE NEW STONE.

If Mr. Ransome has not found the philosopher's stone, he has at least produced a stone worthy a philosopher, and which promises to become the stone of the ages; for it appears to have the elements of great durability, and it certainly possesses every other quality desirable in building stone, whether for structure or ornament. Although five years are not five centuries, chemistry has analysed

even the tooth of time, and can produce, within the period of a comparatively brief experiment, results identical with those of ages of atmospheric corrosion and disintegration. Mr. Ransome's stone has been boiled, and roasted, and frozen, and pickled in acids, and fumigated with foul gases, with no more effect than if it had been a boulder of granite or a chip of the blarney stone. It has been boiled and then immediately placed on ice, so as to freeze whatever water might have been absorbed, and it has been also roasted to redness, and then plunged in ice water, but without any sign of cracking or softening, superficially or otherwise. Nor does its durability rest alone upon such evidence as this, for it is of the simplest chemical composition; and chemistry and geology alike testify to the durability, if not the indestructibility, of a stone which is nearly all silica, like flint, and onyx, and agate, and jasper. It has no oxidizable constituent; for silica, or silicic acid, is already oxidized, and thus it is unalterable in air; and as the new stone is almost impermeable, it will suffer little, if any, injury from moisture or frost. We may then, as the lawyers say, "admit" the durability—and if we insist upon further evidence, only posterity, say in the twentieth and twenty-first centuries, can have the benefit of it, and no doubt Mr. Ransome will bequeath plenty of test-blocks for their satisfaction—and the stone is everything else that can be desired of a building stone, or of a stone for external ornament, excepting, of course, that it does not polish.

And how marvelous, for its simplicity and beauty, is the process by which this stone is made! Some toiling mason or other, hewing in the quarry or in the builder's yard, must have wished, before now, that stone, like iron, might be melted, and run in moulds, even though his own occupation were thus at an end. Did he ever, when by the sea-shore or by a sand-pit, think of cementing indissolubly together the countless millions of grains into solid rock? Mr. Ransome, no mason, however, unless he be, as he may be for anything we know, a member of the mistic brotherhood, *did* think of this. And he tried every cement he could lay his hands to, and did not succeed. The sand became little else than mortar by such sticking as he could effect. But he found out at last—and we are speaking of a time more than twenty years ago—that the best sandstones were held together by silicate of lime. And so he set himself to work to produce this substance, indirectly, from flints, of which plenty could be found for the purpose. But the flints had to be liquefied first, and how could this be done? Not by heat, nor would caustic soda touch them,—so the chemists said. Flints might be boiled in a caustic solution for a week together, so long as the boiler was an opon one, and lose very little by the operation. But by and by Frederick Ransome made one of the most unexpected discoveries in chemistry, viz: that when boiled in a caustic solution, *under pressure*, flints would melt almost like tallow before the fire. But we are not about to give the long history of the invention. With flint soup, or silicate

of soda as a liquid, the question was what other liquid would, in mixing with it, turn both into an enduring solid? What other liquid would turn both into silicate of lime—the substance he was seeking? When he found that chloride of calcium (in solution) would, when mixed with silicate of soda, turn both into flint, or something very much like it, the road was clear, and the manufacture of stone from sand was as simple and as beautiful a process as the making of Bessemer steel from pig iron by blowing air through it when in the melted state. Chloride of calcium had been, chemically considered, a very respectable married couple, known as Ca and Cl. There was a little bigamy attaching to silicate of soda, but the principal parties to the marriage were silicium and natrium, or Si and Na. But, as has happened before now with organic bodies, these inorganic couples, on their introduction to each other, at once ran away with each other's husbands and wives. Si, although still keeping his wife O, took Ca and became silicate of lime, while Cl and Na were like Lot's wife, turned into salt, or chloride of sodium, for their wickedness.

On Friday last, a party of about one hundred and eighty gentlemen, comprising heads of public offices and boards, chemists, geologists, engineers, architects and others, visited the new works of the Patent Concrete Stone Company, at East Greenwich, and adjoining the new steel works of Bessemer Brothers—and this reminds us that Mr. Bessemer has taken an interest, both scientifically and pecuniarily, in the new manufacture. Mr. Ransome showed and explained the whole process of making stone from sand, and exhibited some hundreds of the objects and ornaments, many of them of great beauty, already made to the order of architects and builders of various new buildings in England and abroad. His visitors were the Hon. Gerald Talbot, Major General Willoughby, Sir Proby Cautley, K.C.B., Sir H. Montgomery, Bart., Sir Arthur Cotton, Major General Cotton, Colonel Macdonald, Captain Burstall, R.N., Colonel Smith, Professor Donaldson, Professor Ansted, Professor Tuson, Professor Kerr, Messrs. George Godwin, F.R.S., G. W. Barry, Thomas Blashill, Henry Curry, J. P. Seddon, C. F. Hayward, Thomas Page, Edward Woods, John Grant, John Brunton, Henry Bessemer, Bryan Donkin and many others.

The sand, a clean-grained, slightly brownish sort, just such as a dishonest grocer might select for increasing the gravity, specific or otherwise, of his sugar, comes from near Maidstone. There is no end to the quantity of it, and we believe it costs less than three shillings a ton in the Thames. There are flints, enough for a hundred years to come, brought up from the chalk pits at Charlton; and the caustic soda and the chloride of calcium, the latter a waste product of soda manufacture, are bought of the wholesale chemists. The silicate of soda is made from the flints and caustic soda as follows: The flints are heaped upon iron grating within a series of cylindrical digesters, of the material size and form of small steam boilers. A solution of caustic soda is then added; the digester is then closed

steam-tight, and the contents are boiled by steam of seventy pounds, taken from a neighboring boiler, and led through the solution in a coil of iron pipes. The solution of caustic soda is prepared of a specific gravity of about 1·200. The flints are dissolved into "soluble glass," and are drawn off in that state, as a clear though imperfectly liquid substance, which is afterwards evaporated to a treacly consistency and color, and of a specific gravity of 1·700.

The sand is completely dried, at the rate of two tons an hour, within a revolving cylinder, through which hot air is forced by a centrifugal fan. A small portion of finely ground carbonate of lime, say Kentish rag, or even chalk, is mixed with the sand, the more closely to fill the interstices; and each bushel of the mixture is then worked up in a loam mill, along with a gallon of the silicate of soda. Thoroughly mixed with this substance, the sand has a sticky coherence, sufficient to enable it to be moulded to any form, and when well rammed, to retain its shape, if very carefully handled. In this condition—moulded, of course, and anything that can be done in founder's loam may be done in this sand, sticky with silicate of soda—in this condition it is ready for the solution of chloride of calcium. The instant this is poured upon the moulded sand, induration commences. In a minute or so we hardened little lumps of sand, so slightly stuck together by the silicate of soda that we could hardly keep them from falling to pieces within the fingers, into pebbles so hard that they might be thrown against a wall without breaking, and only a short further saturation was necessary to indurate them throughout. In other words, on the instant of contact, the silicate of soda and the chloride of calcium mutually decompose each other, and re-unite as silicate of lime and chloride of sodium, the former practically indestructible in air, the latter, common salt, perfectly deliquescent and removable by washing, although the stone, *after* the washing, is impermeable to water. Plaster of paris does not set quicker than silicate of soda and chloride of calcium.

The chloric solution is first ladled upon the moulded sand, and, the hardening going on, the objects are afterwards immersed in the solution itself, wherein large pieces are left for several hours, the solution being boiled in the open tanks by steam led through it in pipes. This expels the air which may have lodged in the stone, and possibly heightens the energy of union with the silicate.

After this the stone is placed, for a longer or shorter time, according to the size of the object, under a shower bath of cold water. This is not, by bathing, to convert it into Bath stone, although were the Bath stone a sand-stone, instead of an oolitic formation, this name would do as well as any. The salt, or chloride of sodium, deposited throughout the interstices, is sought out and washed away in brine by the water, and were it not that a portion of undecomposed chloride of calcium was also washed out, this brine might be profitably evaporated for common salt. Now this searching out of the salt by the water would appear to prove that the stone was per-

fectly permeable, but, by one of those paradoxes with which chemistry abounds, the stone, when once freed from salt, is almost impermeable. The action is one which, if it can be explained at all, can only be explained as one of the phenomena of dialysis, as experimentally investigated by Professor Graham. There is no doubt whatever that salt has been deposited everywhere throughout the stone, no doubt that it is afterwards completely washed out, and yet the stone as effectually resists the passage of water afterwards as if it were granite or marble.

It is not necessary to describe the variety of objects that may be made in the new stone. It is practically a fictile manufacture, although not indurated by fire, and unlike fictile goods, having no shrinkage or alteration of color in the making. Whatever the required size of the finished stone, it is moulded exactly to that size, with no allowance as in moulding fire-clay goods or in pattern-making for castings in iron. The heaviest blocks for works of stability, and the most elaborately ornamented capitals, tracery, or copies of statuary, may be made with almost equal facility. For any purpose for which natural stone has ever been used for construction or architectural ornament, the artificial stone will fitly take its place. Mr. Fowler has used it extensively in the stations of the Metropolitan Railway; Messrs. Lucas Brothers have used it with success in various works; several manufacturers at Ipswich and elsewhere have the bed-stones of their steam-engines, steam-hammers, oil-mills, &c., formed of the new stone. Mr. Ransome has moulded a large number of Ionic capitals for the New Zealand post-office, and still more richly embelished capitals, modelled from those of the Erectheum at Athens, for public buildings at Calcutta, besides a great amount of decorative work for English architects. We understand that some thousands of Corinthian capitals of this stone are specified for the new St. Thomas' Hospital, and the architects of the Grand Hotel (Cranston's) of New York, of which we published an engraving in *Engineering* of August 17th last, have decided to employ it for all the decorative work of the grand court of that edifice.

While, however, the new stone affords every facility for ornamental moulding, we consider that its more important purpose is as a substitute for ordinary cut building stone, and for that employed in pilasters, window dressings, garden balustrades, &c. It is truly the stone for the million, as well as for the mullion, and ought to take the place of stucco for exterior work in our town houses. We have not heard that the workmen have set their faces against it, although an intimation of this sort would not surprise us, but we should suppose that a proper knowledge of its advantages would insure its general adoption in spite of any possible opposition of this kind. We believe it to be the fact that builders are slow to move; but there are always exceptions, and, as in other trades, great improvements like this will make way against all opposition.

On the visit to the new works, on Friday, Mr. Dines made an

experiment upon two cubes of the new stone, each four inches square, and made only ten days before. One took forty-four and the other forty-eight tons to crush it. Mr. John Grant, the assistant engineer to Mr. Bazalgette, of the Metropolitan Board of Works, also made experiments on the same occasion, on the tensile strength of the stone. Specimens having a sectional area of two and a fourth square inches bore, respectively, eight hundred and seventy pounds and twelve hundred pounds. These specimens had been made but five days previously.

The new works of the Patent Concrete Stone Company have been laid out upon a large scale, and admit of easy extension. They are already engaged upon a large amount and a remarkable variety of work, and it cannot be doubted that the excellence and great cheapness of their manufacture, the former now proved by nearly every test known to engineers, architects, chemists, and builders, will rapidly secure for it a vastly wider introduction than it has yet attained.

EUROPEAN NOTES.

By Mr. Caleb S. Hallowell.

Our esteemed friend, Mr. Caleb S. Hallowell, having favored us with some valuable notes of places and things met with in his present rapid tour through Europe, we propose to present to our readers such portions as will prove of interest to them, as recording the progress of improvement, or as recalling the memorable works of past time, to which we owe so much of our present knowledge and power. Were our space less limited or our field more general, we should give with pleasure the whole of Mr. Hallowell's entertaining letters, which we are sure would be read with great interest. After some general account of his voyage and arrival at Paris, from which place he started at once for Italy, Mr. Hallowell continues:

"At Lyons we only stopped for the night, and sufficiently long next day to take an outside view of the city. Great improvements are taking place in the way of straightening streets, laying out fine Boulevards, &c., as in Paris. From Lyons we passed directly to Nismes, in the south of France, to examine its antiquities. We all felt it an epoch in our lives, as we gazed upon the grand old Colosseum there, and called to mind the wonderful people to whom it owed its origin. They have disappeared it is true, but not without having *burned* their impress into the very hearts of all civilized nations of the earth. Very costly and extensive restorations are now going on

in the building, under the direction of the French government, which will require a vast amount of cut stone, for their completion.

"We visited, also, with great interest, the numerous other Roman remains, in and about the town. From Nismes we proceeded directly to Marseilles, where we arrived on the 6th of May, stopping at the 'Grand Hotel de Louvre et de la Paix,' a very fine house, the charges in which were just one-fifth of what we paid at the Hoffman House, in New York, and the accommodations greatly superior. Marseilles is the New York of France, and very well deserving of the name. On the afternoon of our arrival, we took a ten miles ride around the harbor and parts adjoining; examined the superb breakwater formed of massive blocks of concrete, the great Scriptural looking jars of olive oil, baskets and sacks of the finest oranges, bags of sulphur, cases of bottled oil, bales of skins, hogsheads of madder, wheat from a dozen different countries, and all the other products that go to make up the life of a busy sea-port. An admirable road has recently been made, bordering upon the sea, which is built up with beautiful villas, the high rocks in the rear being dense with matted evergreens. We noticed for sale on the docks, by the fish women, several kinds of muscles, a very small oyster, and a sort of zoophytic looking animal which they called a violet, resembling an oyster in taste. We spent in Marseilles, very improvingly, the half of the following day, and then took rail for Nice, distance one hundred and forty miles, a large part of the route being one vast expanse of olive groves, interspersed with fig trees; of the latter we saw numbers ten and twelve inches in diameter.

"Shortly before arriving at Nice, we had our first view of the snow-clad Alps, and our first scent of the delicious odors of the orange groves. The rivers in these regions are curious looking affairs, being at one time an almost dry bed, and at another a terrific flood, requiring heavy masonry and skillful engineering to confine them within reasonable bounds. They have at Nice a grand promenade (des Anglais), looking out upon the sea, and bordered with elegant mansions. Riding out to Villa Franche, we had an opportunity to see the semi-tropical foliage; donkeys loaded with great packages of the edible pine burr, women gathering orange blossoms, and numberless other operations that served to remind us that we were in a foreign land. We also visited a manufactory of scents and waters, the laboratory of which was laid open to our inspection.

"From Nice we took steamer to Genoa, and the weather being fine,

we had a near and satisfactory view of the entire coast (in fine weather the steamers hug the shore). The railroad is being prosecuted all along the route, but is proving a most expensive work. In tunneling the rocky promontories, lateral holes are run out, through which the excavated material is discharged into the sea. I was astonished to note the number of towns along the coast; at one time there were twelve in view of the unassisted sight. Oil and wine are both *floated* to the entre-ports, in hogsheads, for vessels can only load and discharge where there are break-waters.

"We arrived at Genoa on the evening of the 9th. Many of the streets are extremely narrow. Wandering out after dusk, we were making our way through what appeared to be an alley, when, lo! we came plump upon the Merchants' Exchange, and found ourselves in a crowded street about twelve feet wide, bordered with the most elegant shops. The street was paved with stone slabs. No vehicles were allowed in it; it was brilliantly lighted with gas; the houses on each side were very high, and old and crooked, with coats of arms over the doors, and statues here and there against the walls. The whole scene, involving as it did the red-capped men, the singing girls and the magnificent collection of silver filagree work, exposed under your very touch, was calculated to leave a deep impression on the mind. We visited the churches, palaces and other public buildings of Genoa, and found much to interest us. At the Town Hall we were kindly shown three letters, written to the authorities of Genoa by Christopher Columbus, in one of which he affectionately says, 'Though our bodies are in a distant spot, our hearts are with you.'

"In this quaint old city the principal hotels are all down close upon the water's edge—you land at the Custom House, go through it, and on the opposite side of the street are the hotels. You enter them through rough old archways, said to be of Roman origin. It seems an odd way of entering a hotel, but once in, you find delightful quarters. Indeed, I have rarely found, in any land, a house superior to the Hotel de la Croix de Malta. The building was once a palace, belonging to the Knights of Malta, and is of unusual strength and solidity.

"We left Genoa at 9 o'clock on the evening of the 11th, and arrived at Leghorn next morning. From here we visited Pisa, the trip being accomplished in a half hour, by rail. The country is flat and mostly intersected by creeks that are navigable by small vessels. Pisa is a walled town; the walls appeared six or eight feet thick, and

some twenty feet high, with brick turrets. The Arno is a running stream about three hundred feet wide. We dashed across the stone bridge, and rattled over the elegantly slabbed street, until a sudden turn brought us in full face of the Leaning Tower. There it stood in all its majesty! It felt as an old friend, and yet looked strange and new. It seemed somehow as though it should be further off, or misty, or indistinct. It was more sharp and clear, and solid and white, than I could at first realize. It did not stand over-topping a street either, as I had from some cause imagined. Neither was it so terrible a trial to the nerves to stand under it, as I had anticipated. I experienced peculiar emotions in gazing upon that structure—feelings that can be better conceived than expressed. We reserved our ascent of the Tower for the close of the visit.

"The Cathedral, like all others in Italy, is filled with gorgeous works of various kinds—paintings, sculpture, carving and mosaics; but my whole attention was at first engrossed in the contemplation of the chandelier—the chandelier that is connected with the name of the illustrious Galileo—the germ of all our clocks.*

"In the church service here, illuminated parchment music books, four hundred years old, are used—great ponderous affairs that lock up like a chest. Over the altar is a vast dome of glass mosaic, seven hundred years old, which permits light to pass through something after the manner of ground glass. There is worked in it a stupendous figure of Christ, uncouth enough to betoken any amount of antiquity. The whole affair is wonderful as a work of useless industry.

"In the Baptistery (which is a separate building) there is a splendid ancient font, carved and inlaid to an incredible extent; the diameter is about fourteen feet, octagonal, with the bottom of black and white marble, cut serpentine. It produces upon the eye a peculiar dazzling effect, and when filled with clear water must be striking. But of all the delightful sounds we ever heard, the echo here was the most wonderful. The deep, rich voice of the guide, in singing a few notes, is reflected by the arched ceiling, and prolonged and worked up into the music of the most melodious organ.

"The great old city wall surrounds the Cathedral grounds, and we

* It was an observation of the equality, in time of vibration, exhibited by the chandelier in this building, swinging through longer and shorter arcs, which led Galileo to his discoveries regarding the laws of motion of falling bodies, which laws were demonstrated by experiments tried from the leaning tower.—Ed.

went under its shade, and reclining upon the green grass, devoted some time to a contemplation of this Baptistery—a singular structure, a concentration of the peculiar and ornate.

"The Campo Santo, too, is another of the curious buildings of this Cathedral group—it is a tremendous sort of a Westminster Abby of a burying ground, the walls lined with antiquated frescoes, the pavement filled with vaults, and the sides studded with mosaics and ancient sarcophagi, brought from distant lands—a strange medley. The large open space enclosed by the building, contains holy earth, brought from Jerusalem, which is supposed to possess special properties, fitting it for its purpose here.

"We terminated our visit by an ascent of the Leaning Tower. The effect, in winding one's way around, is singular—the steps on one side being, of course, more difficult to climb than on the other. But to me the soul of the occasion was Galileo—to think that I was actually treading upon stones hallowed by his foot-steps! I loitered behind the others of the party—I went out upon the different stages, and studied the structure of the wonderful pile. In places the stones were clamped with iron. There were also, in many parts, old rusty nails driven into the mortar. I wrenched out one—it may be one that Galileo himself had driven, in the performance of his experiments upon falling bodies. In any event I will retain it as a memento.

"The top of the Tower is not built of pumice or any material lighter than the bottom, in fact there is not the slightest evidence that it was built in this inclined manner.

"The view from the summit was grand, the sea being visible for an extent of many miles.

"As we drove rapidly away from this famed structure, we looked back to see it over-topping the common-place buildings by which it is surrounded, and in taking our last look we experienced something of the feelings of parting with an old and valued friend.

"I will endeavor in a subsequent letter, to give you some account of Vesuvius and the Grotto del Cane.

"I remain truly your friend,

"Caleb S. Hallowell."

A READY APPROXIMATE TEST FOR IRON.

By Ed. F. Moody, A.M.

Having observed the almost constant presence of small quantities of iron in solutions, I have frequently found it desirable to gain an approximate idea of the proportion, by an easy method and at a moment's notice. Not meeting with any formula to that effect, I prepared the following table for my own use:

One grain of iron per-hydrogen was dissolved to sesquichloride, and thrown into a pint (7291 grs.) of distilled water, and each measured addition of water well stirred in before testing. The tests applied were saturated solutions of ferro-cyanide and sulpho-cyanide of potassium. Small tubes were used, unless otherwise indicated. No time was allowed, to observe whether a precipitate fell or not, indications being as to color only.

Although the color produced by sulpho-cyanide was permanent as long as observed, yet, as it was possible that a trace of nitric acid might be present, or that a portion of the proto-chloride might not have been changed into the per-salt, the same experiment was repeated, varying the iron solution. In this case iron per-hydrogen was heated in an atmosphere of dried chlorine gas and 2·93 grs. (equal to one grain of iron) of the dry crystals of sublimed sesquichloride were dissolved and poured into distilled water, as before, and another portion of the crystals tested for proto-salt. The results did not differ sensibly from the first experiment.

As an aid to the memory, the weight of the liquid measure is recorded to the nearest 10,000 grains.

I.—With Ferro-cyanide of Potassium.

Liquid Measure.	One part of iron in parts of solution.	Color.
One pint.....	7·291	Deep.
	30·000	Light.
One gallon.....	60·000	"
	90·000	Faint.
Two "	120·000	"
	140·000	Mere tint.
Three "	175·000	" in large tube.
	200·000	Extremely faint upon looking down a full 6-inch tube over white paper.
	220·000	" " "
Four "	230·000	No trace.

The examination was continued from this point with sulpho-cyanide, due precaution being observed to keep the liquid slightly acid.

II.—With Sulpho-cyanide of Potassium.

LIQUID MEASURE.	ONE PART OF IRON IN PARTS OF SOLUTION.	COLOR.
Four gallons	230·000	Deep tint.
Five "	300·000	Medium tint.
Six "	350·000	Faint "
Seven "	410·000	" "
Eight "	470·000	Very faint tint.
Nine "	525·000	" " "
Ten "	580·000	" " "
Eleven "	640·000	" " " large tube.
Twelve "	700·000	Extremely faint upon looking down a full 6-inch tube over white paper.
Thirteen "	760·000	" " "
" and half.....	790·000	"? "? "?
Fourteen	816·000	No trace.

To apply the above, carboy chloro-hydric acid gives a deep blue with the ferro-cyanide, or one grain of iron in about a quart. B and C's common HCl gave a much lighter color, or about one grain to the gallon. A sample of refined sulphate of zinc corresponded to one grain of iron in four to five gallons of the saturated solution. It was evidently purified, according to the indications afforded by ferro-cyanide. A sample of pharmaceutical chloride of zinc, regarded as pure, appeared to contain one grain in 450,000, or about seven to eight gallons.

From the London Mechanic's Magazine, July, 1867.

ELECTRO-CAST BRONZES.

In a former article on the English bronzes in the Paris Exhibition, we referred to the advantages of electro-casting over pyro-casting, and adverted to an erroneous impression generally existing as to the want of solidity of the former as compared to that of the latter, and then promised to give a detailed account of the process of electro-casting to assist to remove that erroneous impression. We will now attempt to redeem that promise. We will begin by assuming that the model is formed in clay, or that a plaster cast is taken from it in portions of suitable size for the convenience of casting, if the figure be large, or if small in one piece. Each portion is first saturated with boiled linseed oil, or some suitable varnish, to prevent it

absorbing moisture. It is well coated with black lead to make it conduct electricity. It is then bound round with strong strips of copper, not only as supports while suspended in the solution, but also to serve as conductors; besides these, wires are passed round in various directions, to assist the depositing copper to spread more rapidly. The model is then suspended in the solution surrounded by plates of ordinary commercial copper; these plates being connected with the copper pole of the battery and the figure with the zinc. The surface of the zinc exposed in the battery should equal about the surface of the figure to be coated; this is not absolutely necessary, but it is the best proportion. The battery used is usually a single cell Wollaston, or rather single element, for the elements in different cells may be connected in single series so as to gain sufficient surface. The depositing solution is the ordinary sulphate of copper nearly saturated, and slightly acidulated to make it a better conductor. The figure is allowed to remain in the solution till it is coated to about the $\frac{1}{8}$ of an inch, or thick enough to perfectly retain the form of the figure when it is removed from the inside.

So far, this is all easy enough to manipulate; but to deposit the figure inside this mould is not so easy; for the dissolving plates have to be inside also. This is most difficult to do in the fingers and that part of the drapery where there are folds. To accomplish this, portions of the mould are cut out, that dissolving plates or bars may be inserted; but here is the difficulty, in such narrow places as the folds of the drapery, or, for example, the skirt of a coat, that these dissolving plates are in danger of coming in contact with the mould, and if one should do so, all deposit would be stopped. To avoid this they are covered with flannel or other porous material to prevent metallic contact. The portions that were cut out are also prepared, and the same thickness is deposited upon them as in the mould. To prevent copper being deposited on the outside of the mould and on the outside of the portions cut out, they are coated with a composition formed of beeswax, rosin and Venetian red, which will not conduct electricity. All these precautions being taken and a sufficient number of positive plates or rods being suspended within the mould, the metal is then allowed to be deposited tranquilly till the required thickness is obtained. Still, continual attention has to be given to it, for if the solution should become nearly saturated and the temperature should not drop sufficiently, crystals of sulphate of copper will be formed on the mould and on the dissolving plates. This may take place, though the solution at the commencement was considerably below the point of saturation; for after standing tranquilly for some time it is liable to settle in strata of different densities, and at night, in winter time, when this happens, crystallization is sure to take place. In summer, though the temperature may not be liable to drop so far as to cause crystallization, yet there is another danger to be dreaded when the solution settles into strata of different densities.

It is well known to electro-metallurgists that electric action may

be set up by means of one metal in one solution if the solution be of different densities at the top and bottom. Then the metal becomes positive at the bottom and negative at the top. This may take place in the depositing vat; and certainly will, if by any means the battery power should drop below a certain point. Nevertheless, by due care all these evils can be easily provided against, and the deposit then goes on steadily and certainly. To ascertain when the deposit is of sufficient thickness, a pair of long-limbed double callipers are used, the mould having been gauged at the commencement. When electro-casting was first practised, some difficulty was found in depositing the metal of sufficient toughness; but now it can be deposited of any degree of toughness and hardness required, even harder and tougher than hard-rolled sheets. The different degrees of hardness, toughness and brittleness, depend upon several conditions. If the solution be an acid one, and the electricity of large quantity and low tension, the metal will be brittle; but if the solution be a neutral one, and the electricity of small quantity and considerable tension, the metal will be hard and tough, every condition as to quality of metal being perfectly at the command of the operator, that is, if he knows his business. Each part of the figure having acquired the thickness desired, the whole is removed from the vat, and each part is suspended before a large fire to melt off the composition which has protected the outside of the mould. The mould is then stripped from the figure, which has been deposited within it, and the portions are then fitted together and riveted, all seams and marks being hammered out and chiselled over, and the portions which have been deposited on the pieces which were cut out of the mould to allow of the dissolving plates being inserted in the folds and in other places which were otherwise inaccessible, are hard soldered into the places left in the figure for them. The figure is then placed on its base, which is sometimes a simple brass casting slightly electro-coated with copper; the whole being washed with a browning solution, the work is finished. It will be clearly seen by the details of this process, that there is more certainty of reproducing exactly the work of an artist than by pyro-casting. In fact, this is the only method by which an exact copy can be produced, there being no expansions or contractions to allow for.

From the London Mechanics' Magazine, July, 1867.

AGRICULTURAL BOILER EXPLOSIONS.

If any apology is necessary for our frequent recurrence to the subject of steam-boiler explosions, it is assuredly to be found in the frequency of the explosions themselves, as well as in the carelessness, or rather, culpable negligence, of some makers and some attendants. In the present instance, we have both of these parties promoting a

catastrophe by which eight lives were sacrificed and four persons were injured. The boiler belonged to an engine of the agricultural class, and the fact that too little attention is paid to the fitting as well as to the working of these engines, induces us once more to raise a protest against such a condition of things as these boiler explosions too frequently disclose. The explosion occurred in March last, at a farmstead, the boiler being of the portable multitubular agricultural type, and employed for driving threshing machines. On exploding it was rent into two main fragments, the fire-box with the flue tubes being separated from the barrel of the boiler, while in addition the plate forming the sides and top of the outer casing of the fire-box was ripped off. These fragments were scattered right and left, one of them being thrown across the road into an adjoining field, to a distance of forty or fifty yards. Unfortunately, the explosion occurred at dinner time, when the workpeople had clustered round the boiler for the warmth it afforded them on a cold day with a biting east wind, the result being that eight of them were fatally injured, and four more were wounded. From the report of Mr. Fletcher, the engineer, to the Manchester Boiler Association, the cause of the explosion appears to have been of the simplest kind. The engine-driver was seen shortly before the explosion, to be working the boiler with the safety-valve lever tied down by a cord, so that as soon as the engine was stopped for the dinner hour, the boiler burst from accumulated pressure. The engine-driver was amongst those killed, and there can be no doubt of his suicidal negligence. It should, nevertheless, be pointed out that the complement of fittings with which the boiler was equipped, was very inefficient, and had it been as complete as it ought to have been, there is every ground to conclude that the explosion would have been prevented and the lives saved.

We thus see that the maker is to some extent responsible for the result, for in the case of farm engines, the users, and much less the attendants, can hardly be supposed to discriminate between well and ill-appointed boilers. Thr boiler in question had no pressure-gauge nor duplicate safety-valve. Had there been a steam-gauge it would have indicated the excessive pressure, and had there been a duplicate safety-valve of suitable construction, the attendant could not have gagged it simply by a cord. We do not pretend that any safety-valve is proof against the attacks of skilled malice, for anything that can be made by one man can be deranged by another. But the safety-valves on portable engines are simply exposed to the negligence and stupidity of ignorant men, and there are valves which would to a very great extent meet the case. At any rate, the best appliances should have a fair trial, and portable engines ought no longer to be allowed to work thus inefficiently equipped. A careless man may make them as dangerous as a powder magazine, simply by tying down the safety-valve lever, or by giving an extra turn to the thumbscrew on the spring balance.

EDUCATIONAL

(Continued from page 134.)

THE MAGIC LANTERN AS A MEANS OF DEMONSTRATION.

Condensers.

THE part played by the condenser in a magic lantern is one much more important than is generally supposed. In the first place, it performs the double office of collecting the scattering rays of light from the lamp or ignited lime, and causing them to pass through the object, and also of concentrating them, so that they shall all fall within the circumference of the object-glass.

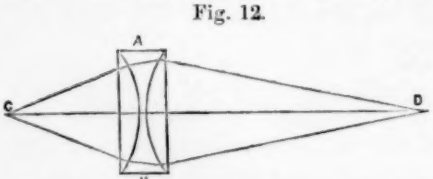
To fulfill these conditions it is essential that, while the light is at one point, say G, Fig. 11, a little beyond the principle focus, the conjugated focus, or G′, should fall near the objective. In fact, this point G′ must be *beyond* the objective, for reasons which will be given hereafter.

Fig. 11.

Considering the above conditions alone, we see that a condenser should be of greater diameter than the largest object to be exhibited and yet of as short focus as possible; for the shorter the focus the nearer may the light be brought, and hence the greater the number of rays intercepted and concentrated by the lens.

To obtain a single lens, of sufficient diameter and short focal distance, is, of course, impossible without the use of curves, inadmissible for various evident reasons. We therefore form condensers of combined lenses. The simplest arrangement is that shown in Fig. 12, where two equal plano-convex lenses are combined, with their curved surfaces inwards and their flat sides outwards. For large objects and low powers this form is very effective, considering its simplicity and ease of arrangement. But then a little thought will show us several objections.

Fig. 12.



With moderate curves its focus will be long and the light being

nearer than the objective, as is indicated in Fig. 12, the rays which pass through the first lens will be still diverging, the marginal ones will therefore be lost on the mounting before reaching the second lens. It would therefore be more economical of light to make this first lens with a shorter focus than the second; or, to save material, the first lens might be smaller than the other, if the curves remain the same.

Such a combination as that of two plano-convex lenses, calculated by Hershel, in which the focal lengths are as two-thirds to one, would be excellent in this case, the shortest lens being placed next the light and the convex surfaces towards each other.

Besides the simple combinations of two lenses above described, many varieties are in use, in which three lenses are employed; by which means it is possible to secure a shorter focus and therefore better illumination, as well as other advantages. In this case, the first lens should be a plano-convex of very short focus,—in fact of such a curve that the proposed focus or position of the source of light shall be nearly at (but a little beyond) its centre.

Many writers have recommended that this lens should be a meniscus, from the impression that a loss of light by reflection at the first surface, which would thus be prevented, is of some moment.

But if we take for example an extreme case, where, with a lens of three inches diameter, the light is but one inch and a half off, the angle of the very marginal rays would be forty-five degrees with the surface, at which the loss by reflection is less than five per cent., this being only for the extreme edge, and diminishing rapidly with the increase of angle towards the centre.

By substituting a meniscus, with concave surface, having a radius of about three inches, we should diminish this loss somewhat, bringing it, in fact, to about two and a half per cent., but in so doing we should seriously lessen the converging power of the lens, and by reason of additional lenses or greater curves, thus made necessary, lose more than we gained by the arrangement.

The relatively greater cost of meniscus lenses is also worthy of consideration.

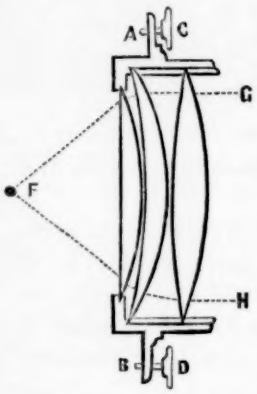
Again, the condenser ought to prepare the rays in a special manner for the action of the object-glass. The discussion of this point we will, however, leave to a future section on objectives, and as we shall see then the correction of spherical aberration in the condenser has a very important effect upon the working of the object-glass, even in

the simple magic lanterns, and when the apparatus comes to be applied to higher uses, as in the gas microscope, this correction is of great moment, because it gives us that accurate concentration without which it is impossible to avoid fatal loss of light in the minute lenses of high powers. The general reason why condensers should have their spherical aberration corrected being thus given, we will proceed to describe some of the means by which this end has been sought to be effected.

We shall first describe the plan and combination devised by Dr. C. M. Cresson, of this city, because it involves some very important general principles and is capable of the most extended range of application. In the first place, this combination involves an important general idea, namely, that the condenser having these two duties among others to perform—first, the collection of light from the lime; second, the condensing of the collected light into the objective—it is best to divide it into two parts, one devoted to each object. The advantages of this plan are so numerous that we will not enumerate them here, but leave their discussion for the future, when it will come up naturally in various places.

This combination, then, is to be considered in two parts: first, the collectors, Fig. 13, which, taking the divergent cone of light from F, reduce it to a parallel beam beyond G H. In the special instrument, constructed by Mr. Zentmayer, from Dr. Cresson's calculation, which I have had in use for many years, the lenses employed are a plano-convex next the light, a meniscus and a crossed* lens. The surfaces of these, reckoning from the light, are first, plain; second, 4·5 inch radius; third, 30 inch radius; fourth, 6 inch radius; fifth, 52 inch radius; sixth, 8·75 inch radius. The diameter of the first lens is 4·6 inches, the others 5 inches.

Fig. 13.



The focus of this combination for parallel rays entering from G H is 3 inches, back of the plane surface A B., and its spherical aberration, by practical test, for central rays and those within ¼-inch of the extreme edgde is 0·1 inch.

* Crossed lenses are double convex ones, in which the radii are as 1 : 6 or 1 : 7, giving thus the least spherical aberration for single glasses.

This part of the combination is never changed; whatever we do with rays in a lantern; it can never cause harm to bring them parallel first. The condenser proper (or rather condensers) we change with the work, and have in the above case single crossed lenses of 15, of 10 and of 7 inch focal length, respectively, besides small lenses (extra condensers) of 1½-inch diameter and 1½, 2 and 3 inch focus, used only with the microscope.

These various condensers are shifted on and off as required, so as, without disturbing the light, to give the *best effect* with *each objective*.

There is no reason why the exact combinations mentioned above should be exclusively employed in developing this general plan; on the contrary, we are now working out a combination of shorter focus for the collector, and hope by that means to obtain more light. The combination as it stands is undoubtedly an excellent one and has, in competent hands, produced results with the microscope and polariscope which, as far as we can learn from experienced observers, have never been reached elsewhere. We say competent hands because we do not hesitate to acknowledge that in our own first essays we obtained but miserable results, and it was only after many evenings past in *trials* (in every sense of the word) that we began to see the realization of our hopes.

(To be continued.)

(Continued from page 56.)

LECTURES ON ELECTRICITY AND LIGHT.

Delivered before the Franklin Institute by Prof. HENRY MORTON, Ph.D.

Development of Electricity by Induction.

HAVING studied at some length the direct methods of separating the electric fluids in a statical manner by friction, and other closely allied actions, we next come in natural order to that class of phenomena described by the term Induction, which of late years have become (by reason of various improvements and discoveries) of more practical importance as means of developing electrical force than the first.

Induction may be defined as the action by which the normal electric equilibrium of bodies is disturbed, through the attractive or repulsive influence of others, electrically charged or excited.

According to our theory, an excited body is one which has an

excess of one or other fluid. This fluid, as we have also seen, attracts the opposite fluid in adjacent bodies, and repels that which is like itself; it therefore follows, that if an insulated conductor is brought near to a body charged (say positively), the positive fluid of the insulated body will be repelled to its further side by the positive fluid of the charged one, while the negative fluid will be attracted to the nearer side of the insulated conductor by the same means, and we shall thus have two opposite kinds of excitement, developed in the opposite sides or ends of the conductor, by induction from the excited body; which will have developed this effect without any loss or expenditure of its own charge.

To illustrate this action in the simplest way, we excite a bar of glass, and then bring it within eight or ten inches of a gold leaf electroscope. The leaves will then be seen to diverge, but will collapse at once on withdrawing the excited glass from the neighborhood of the instrument. If a long metallic rod, with rounded ends, is insulated and connected at each extremity with an electroscope, both instruments will show excitement on the approach of an excited glass rod or the like. But if the *kind* of electricity at each end is tested, we shall find it positive at the further end, and negative at the nearer, if the excited body is positive, as a glass rod would be, and the reverse if a negatively excited one, such as sulphur or rosin, should be employed.*

The action of induction, as thus described in a single case, is clearly the necessary result of the fundamental laws of electric action, stated at the very outset, namely, the attraction and repulsion of unlike and like fluids, and the mobility of these fluids on and through conductors, and their incapacity of transfer over or through insulators, among which dry air is conspicuous.

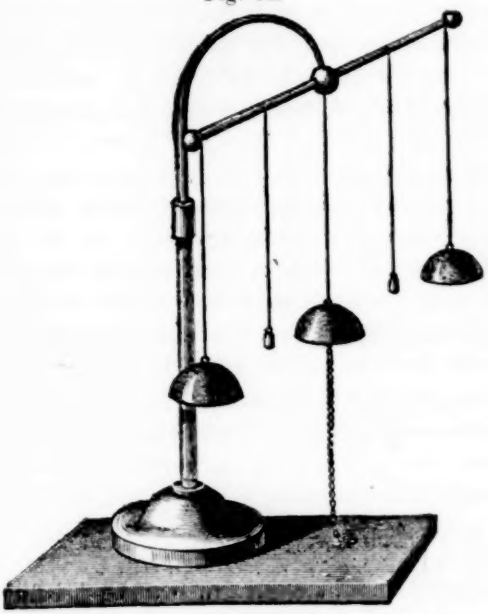
Any elaborate explanation of special cases may, therefore, be dispensed with, and this part of the subject left to the intelligent reflection of the student. A few points should, however, be mentioned before we proceed to the practical applications of this principle. If the conductor, excited by induction, is uninsulated, or is even for a moment connected with the earth, the repelled kind of fluid will

* To distinguish kinds of electricity, such an electroscope as that described in our last number, as made by Hauy, from a crystal of Iceland spar, may be used or such as is shown on page 52 or 53, Vol. LIII., will also answer by feebly charging with fluid of a known kind, and observing whether the first effect of the electric charge to be tested is to increase or diminish the repulsion in the instrument.

escape and an equal quantity of the opposite sort will take its place. (See page 54, Vol. LIII.)

A non-conductor cannot, unaided, be charged by induction; but the fluids in its particles are so polarized (*i. e.* the one kind drawn in

Fig. 13.



one direction, the other kind repelled in the other) that they in their turn repeat and transmit the action, with a loss, however, which varies with their nature and thickness.*

All attraction and repulsion is preceded by induction. Thus in the chime of bells, shown at Fig. 13, the outer bells being positively

* The difference in capacity for transmitting inductive influence, or, as it is called, Specific Induction, may be shown by fixing a charged body at such a distance from the plate of an electroscope, that a slight divergence will be produced. If then a cake of shellac or sulphur be interposed between the excited body and the electroscope, the divergence will be increased, shellac or sulphur transmitting induction much better than air. Snow Harris gives the following table, (*Philadelphia Trans.*, 1842, p. 170:)

SPECIFIC INDUCTION.

Air	1·00	Glass	1·90
Resin	1·77	Sulphur	1·93
Pitch	1·80	Shellac	1·95
Bees' wax	1·86		

charged, the nearer surfaces of the clappers become negative by induction, and these opposites attract. So, also, with repulsion. Bodies similarly charged, are drawn apart by the opposite charge (developed by induction from them) in surrounding objects.

One other point should not be omitted: A charged body in the centre of a spherical cavity, will exert its inductive action equally in all directions, with a force diminishing with the square of the distance; but if a conductor be brought near at one side, nearly all the inductive effect will be concentrated upon it to the exclusion of more distant bodies.

In fact, the less the distance between the reacting bodies, the more perfect and concentrated is the inductive action and polarization of the intermediate insulating particles, until at last the tension reaches such a point in these as to effect a discharge.

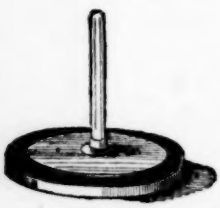
From this fact flows the utility at once, and danger of thin insulators, in apparatus operating by induction; for these, clearly, will both give us the most intense effects and be the most liable to penetration and fracture by the fluids.

Having thus stated, in as few words as we can, the principle of *Induction* and the most prominent features of its action, we will proceed to some of its more important applications:

The Electrophorus.

This instrument and its operation may be briefly explained as follows: It consists, as shown in Fig. 14, of a tin or brass dish or plate, filled with shellac or resin, and of a metallic plate with a glass handle, which may be freely placed upon or removed from the other.

Fig. 14.



We excite the upper surface of the shellac by means of a piece of fur. (Best used by holding it at one end and lashing the plate of shellac with it.) The upper surface being thus negatively charged, its induction is concentrated upon the metallic dish beneath it, which is the nearest conductor, and which, from its connection with the earth, receives a positive charge. The negative charge, on the exposed surface, is thus held down by the attraction for this opposite charge, and does not tend to escape and diffuse itself. When, however, the movable metallic plate is placed upon the excited shellac, the induction will all be determined in this new direction by the greater near-

ness of this conductor, and if the hand or other body in connection with the earth, be brought near, a spark will be elicited, which will represent the escape of negative electricity from, and the entrance of positive into, the movable plate. The charge in the shellac will fail to be carried off by the metal surface, because this will actually touch it but in a few points.

The movable plate thus, as we see, comes to have in it an excess of positive fluid; but this is fixed for the time being, and rendered neutral or inoperative, as regards exterior bodies, by the attraction of the negative fluid on the shellac.

If, however, the brass plate is removed by its insulating handle, then the excess of positive electricity in it will be set free, and may be used for any purpose. It will be seen from this that the original charge in the shellac surface, has not been diminished, and that therefore the same operation may be repeated and a fresh positive charge given to the plate, without any fresh frictional excitement of the shellac.

The indefinite development of electric force in this way, therefore, reduces itself to a mere question of mechanical movement, by which the conductor shall be made to come within, and to pass beyond, the influence of the excited shellac, connection with the earth being established, of course, at the right time.

To develop this action to its *best* and most effective results, may still be considered a problem open to the future; but an enormous stride has been made in the direction of its solution, in a machine which has been appropriately called the "Continuous Electrophorus," or otherwise, from its inventor, the Holtz Machine. This instrument already, almost at its birth, enormously transcends in power all ordinary sources of electric force, such as the cylinder and plate machines, and finds no compeer, except in the induction coils of large size and ten-fold cost. What it may reach in the near future, time only can show.*

* At the time when these lectures were delivered, one of these machines, which was secured for me by the exertions of Mr. James Swain, in Paris, was the only one in this country. Since then, Messrs. Ritchie, of Boston, and Charles T. Chester, of New York, have undertaken the manufacture of the machine, with many improvements of structure and arrangements. Drawings of these instruments, with descriptions, as well as many points developed by my own experiments, have been published in this *Journal* during the past and present years. Referring, then, to these papers for full information on the above subjects, I will here confine myself to such points as have not before been noticed.

Bibliographical Notices.

A Treatise on Astronomy, Spherical and Physical; with Problems, and Solar, Lunar, and other Astronomical Tables, for the use of Colleges and Scientific Schools. By William A. Norton, M.A., Prof. of Civil Engineering in Yale College. Fourth Edition, Wiley & Son, New York, received from J. B. Lippincott & Co., Philadelphia.

The difficulty of finding text books on scientific subjects, which are up to date of use, is well recognized and inevitable to some extent, so long as the growth of our scientific knowledge, as at present, almost outstrips our steam presses and book folding machines. In one department, however, this difficulty was but little felt until lately. Astronomy, the most venerable of the sciences, seemed to have passed through its period of growth and to have reached that maturity of developement which precludes increase. Its possession of the divinity which belongs to knowledge, and a therefore eternal youth, has been, however, of late vindicated by those vital discoveries and developments which have more or less directly resulted from the application of the spectroscope. These very things, however, have rendered the existing text books obsolete, and it is, consequently, with pleasure that we see this new edition of a standard work brought out, with enlargements and modifications, which bring its records down to the present day and the latest discoveries.

The work before us contains an admirable exposition of the general mathematical questions connected with astronomy, the figures, moreover, being placed in the text (a great convenience, compared with the use of plates); and also, a very extensive discussion of the various physical conditions involved in the subject. It is, in fact, exactly the book to put in the hands of the thorough preliminary student of modern astronomy.

Meteoric Astronomy: A Treatise on Shooting Stars, Fire-balls and Aerolites. By Daniel Kirkwood, L.L.D., Prof. of Mathematics in Washington and Jefferson College. J. B. Lippincott & Co., Philadelphia.

Great interest was naturally excited last year, by the prediction of the meteoric showers of November, and when those who watched were entirely disappointed of any such display as was expected, some doubt was felt as to the soundness of reasoning on which the prediction had been based, and also as to the various corollaries and conclusions resting on the same ground. The European observers were more

fortunate, however, than ours. Their side of the earth seems to have been ahead when she entered the stream of meteoric bodies, and, though the display was by no means of that splendid character which had characterized it at former periods, quite enough was seen to verify the prediction that we should, at the time in question, pass through a swarm of meteoric bodies, and to give much aid in determining the exact position, path, direction and velocity of the cosmical cloud, stream or partial ring.

Thus the Astronomer Royal of Ireland, at the Observatory of Trinity College, Dublin, records 2107 meteors as observed by himself during three hours after midnight, on November 13th and 14th. We cite this case simply because it happens to be at our hand. It is only a fair specimen of the observations generally.

The little book, whose title is given above, furnishes, in an excellent form, a complete collection of all the facts connected with the subject of Meteoric Astronomy, and a clear and most entertaining exposition of the theory which has been proposed to account for that remarkable portion of the celestial system whose phenomena are classified under the above head.

With regard to this theory, we can only say here, that it commends itself at once to common sense and our ideas of probability, and is in entire accord with the received cosmical theories regarding the other bodies of the universe. In conclusion, we can cordially recommend to our readers this little book, which we have ourselves perused with unusual interest and pleasure.

Tyndall's Lectures on Sound.—We have just finished reading the above lectures, which have been printed very handsomely in a collected form, and which we have obtained from D. Van Nostrand, of New York.

This work, while displaying, as a matter of course, great ability and much original thought and investigation, is far inferior in interest to the "Heat as a Mode of Motion," than which there was never, we think, a more entertaining scientific work written. The present book may be regarded as a second part of the former, and therefore, can hardly hope to escape the fate of Paradise Regained, Pilgrims Progress (Part II.) and other *continuations*. To all scientific men the work in question will be of the greatest value, on account of its admirable statements of laws and facts, its numerous new and ingenious experiments and its admirable developments of the subject handled; but there is little probability of its achieving that general popularity which so strongly marked its predecessor.